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GEORGE C. MARSHALL **SPACE
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CENTER**

DATA BOOK FOR 12.5-INCH DIAMETER
SRB THERMAL MODEL WATER FLOTATION
TEST - 14.7 PSIA, SERIES P020

NASA/MSFC

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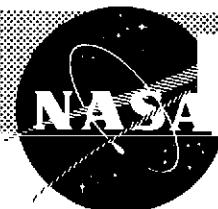
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16. ABSTRACT This report presents data acquired from the initial series of tests conducted to determine how thermal conditions affect SRB (Space Shuttle Solid Rocket Booster) flotation. Included are acceleration, pressure, and temperature data recorded from initial water impact to final flotation position using a 12.5-inch diameter thermal model of the SRB at ambient pressure. The model was 136.9 inches long and weighed 117.3 lbm. Forty valid tests were conducted from July 19 to August 16, 1973. These tests indicated the following differences from ambient temperature tests: 1. Significant negative static pressures can occur during penetration. 2. Maximum penetration is increased. 3. Final flotation is in the spar buoy mode.			
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SUMMARY

This report presents data acquired from the initial series of tests conducted to determine how thermal conditions affect SRB (Space Shuttle Solid Rocket Booster) flotation. Included are acceleration, pressure, and temperature data recorded from initial water impact to final flotation position using a 12.5-inch diameter thermal model (Figure 1) of the SRB at ambient pressure. The model was 136.9 inches long and weighed 117.3 lbm. Forty valid tests were conducted from July 19 to August 16, 1973. These tests indicated the following differences from ambient temperature tests:

1. Significant negative static pressures can occur during penetration.
2. Maximum penetration is increased.
3. Final flotation is in the spar buoy mode.

SECTION I. INTRODUCTION

This report presents processed acceleration, pressure, and photographic data recorded during water impact tests using a 12.5-inch thermal model of the Space Shuttle Solid Rocket Booster (SRB). These tests were conducted from July 19 to August 16, 1973. A description of the model, test procedure, instrumentation, and data acquisition systems is included.

These tests investigated thermal effects on a scale model SRB during impact, penetration, slapdown and final flotation at 14.7 psia by varying the model temperature at water entry. Entry dynamic conditions were varied by using different combinations of vertical velocities and water impact angles. Results from these tests will be used to develop analytical models for the full scale SRB and to indicate potential problem areas.

Forty valid drop tests were conducted.

SECTION II. MODEL DESCRIPTION

The test specimen was a model of the 142-inch diameter Space Shuttle SRB with a flared skirt and a full length nozzle. The model was a rigid body constructed of aluminum alloy 2219-T87 and contained three sections:

1. Cylindrical Section (four segments)
2. Motor Nozzle Section
3. Flared Skirt Section

The dimensions of the model (see Figure 2) were:

- o Length: 136.9 inches
- o Body Diameter: 12.5 inches
- o Skirt Diameter: 16.5 inches
- o Weight: 117.3 lbm
- o Pitch Mass Moment of Inertia: 34.9 slug-ft²
- o C.G. Location (aft of the nose plate): 74.0 inches

Geometric patterns were placed on the model to aid in photographic data reduction. Twenty-four heater strips with a rating of 720 watts were placed around the cylindrical section. Four heater strips (360 watts) were placed on the nozzle outside surface and two strips (120 watts) on the thrust cone. No heater strips were placed on the flared skirt. External insulation (Dow Corning Silicon Paint 93-027) was sprayed on the external surface of the model to a depth of .02 inch.

SECTION III. TEST PROCEDURE

Testing of the 12.5-inch diameter thermal model was conducted in the Over Water Launch (OWL) tank facility at Marshall Space Flight Center (MSFC). The model was suspended above the OWL tank by a quick release device at the specified initial angle. The model height above the water surface was varied to yield the specified impact velocities. After the model was in position for release, power was applied to strip heaters. When the model wall temperature reached the test temperature, the release mechanism was activated and the model was allowed to fall freely. The model impacted tail first with nominal vertical impact velocities of 5, 15, and 30 ft/sec. The nominal off-vertical pitch angles were 0° , 10° , and 20° . Average wall temperatures ranged from ambient to 450°F .

The procedure for drying out the inside of the model after each test was as follows:

1. With the model in a vertical position and the nozzle down, an air supply line was inserted three feet inside the model.
2. The model was heated to 300°F with the air supply operating for 10 minutes.
3. The air supply system was removed and the model was heated or cooled to the test temperature.

The test run number, nominal vertical velocity, initial impact angles and temperatures are shown in Appendix A. Figure 3 shows the coordinate system and defines the parameters used in the test program.

SECTION IV. DATA ACQUISITION AND INSTRUMENTATION

The data acquisition system consisted of acceleration, pressure, and strain gage transducers with their associated signal conditioning electronics, multiplexing equipment, and analog tape recording system. An oscillograph recorder was used to display online measurements during each test drop.

Instrumentation consisted of six accelerometers, two ullage pressure transducers, two ullage and six wall mounted thermocouples. Measurement identification numbers, transducer types, and other pertinent instrumentation details are given in Table 1. Figures 4 and 5 show the instrumentation locations.

Five cameras were placed above and two below the water surface. Two camera systems were used. A high speed (250 frames/second) camera system filmed initial impact and slapdown. This system consisted of one camera above and one below the water level that sighted the impact point along the line of descent of the model into the water. A third high speed camera sighted the impact point from a position 90° away and below the water level. The second system had two low speed (24 frames/second) cameras that filmed the test from release of the model until final flotation mode. The cameras were located above the water level and 90° apart in a horizontal plane.

All data acquisition systems were calibrated in accordance with approved laboratory practices and calibrations were maintained as required.

SECTION V. DATA PROCESSING AND EVALUATION

Onsite data evaluation was performed after each drop. All oscillograms were reviewed to determine the validity of each measurement and time slices were selected for time history plots. Analog data tapes from each test were sent to MSFC Computation Laboratory for reduction. A digitized time history plot for each valid data channel was made with a sufficient time slice to include model release, water impact, slapdown, and rebound conditions. An additional time history plot was made for the pressure and temperature channels which extended these time history plots to a total time of 15 to 30 seconds.

SECTION VI. DATA PRESENTATION

Model impact parameters obtained from photographic data reduction are presented in Appendix A. Parameters included are:

- o Vertical impact angle (deg)
- o Maximum penetration depth (ft)
- o Vertical angle at maximum penetration (deg)

The impact velocities were calculated from accelerometer data which indicates release time and impact time.

Acceleration, pressure, and temperature data time history plots are presented in Appendix B. Acceleration (g), pressure (psig), and temperature ($^{\circ}\text{F}$) are presented as a function of time.

TABLE 1. INSTRUMENTATION PROGRAM

<u>Measurement Number</u>	<u>Measurement Type</u>	<u>Frequency Response (Hz)</u>	<u>Full Scale Range</u>	<u>Sensitive Axis</u>
EP001	Accelerometer	2 - 400	\pm 25G	Pitch
EY002	"	"	"	Yaw
EA003	"	"	"	Axial
EP004	"	"	"	Pitch
EY005	"	"	"	Yaw
EA006	"	"	"	Axial
D0001	Pressure	"	\pm 12.5 PSIG	Internal
D0002	"	"	"	"
C0001	Thermocouple	"	500°F	External Wall
C0002	"	"	"	Internal Wall
C0003	"	"	"	Ullage
C0004	"	"	"	Internal Wall
C0005	"	"	"	Ullage
C0006	"	"	"	Internal Wall
C0007	"	"	"	"
C0008	"	"	"	Internal Wall

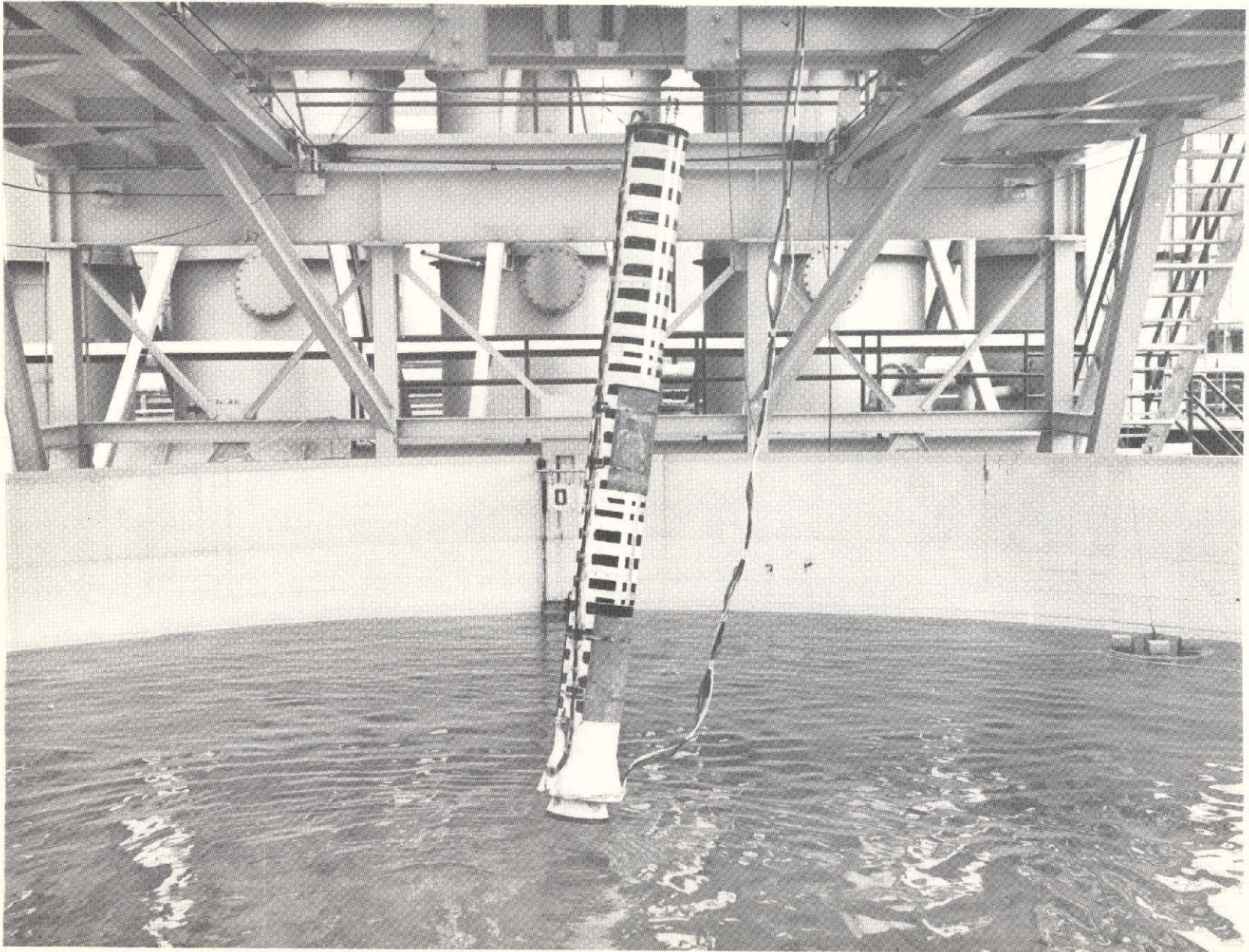


FIGURE 1. SRB TEST MODEL

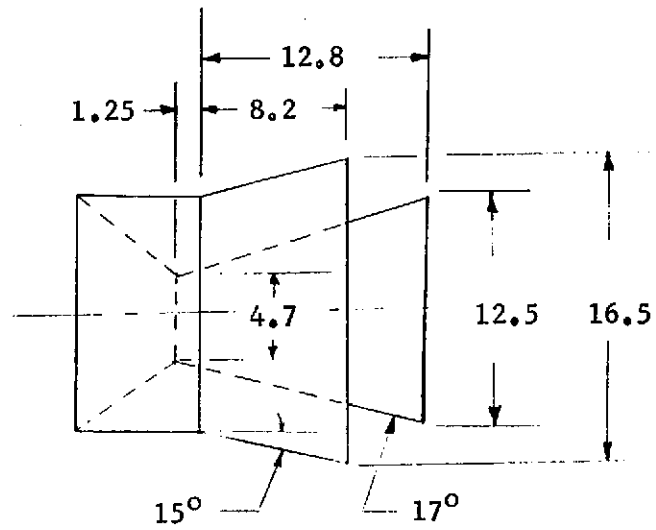


FIGURE 2. MODEL DIMENSIONS

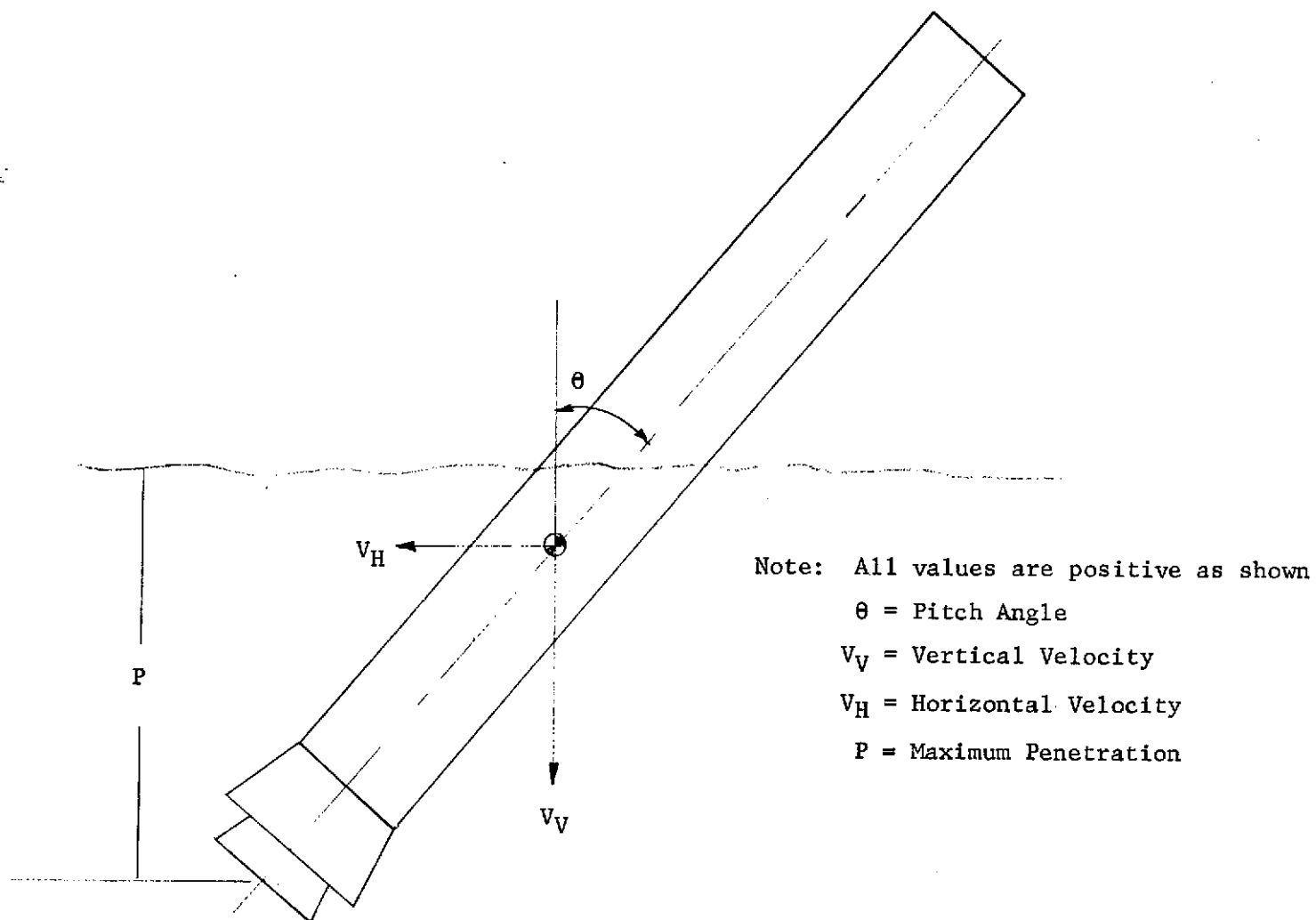


FIGURE 3. MODEL COORDINATE SYSTEM AND PARAMETER DEFINITION

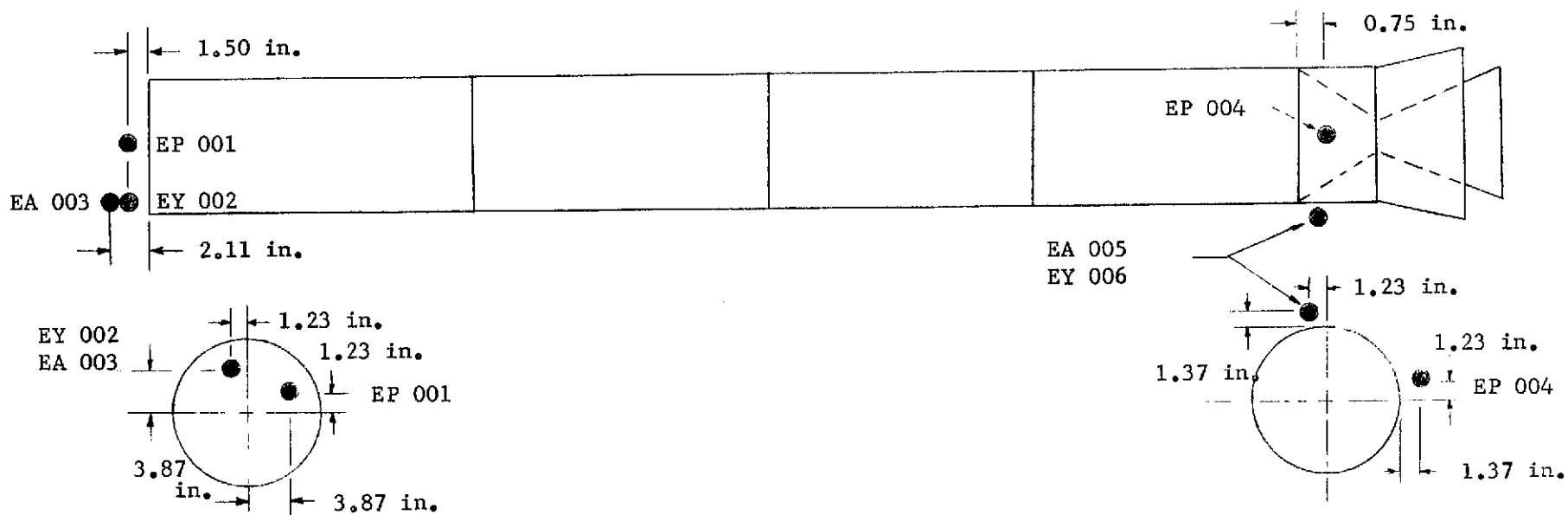


FIGURE 4. 12.5-INCH SRB THERMAL MODEL ACCELEROMETER LOCATIONS

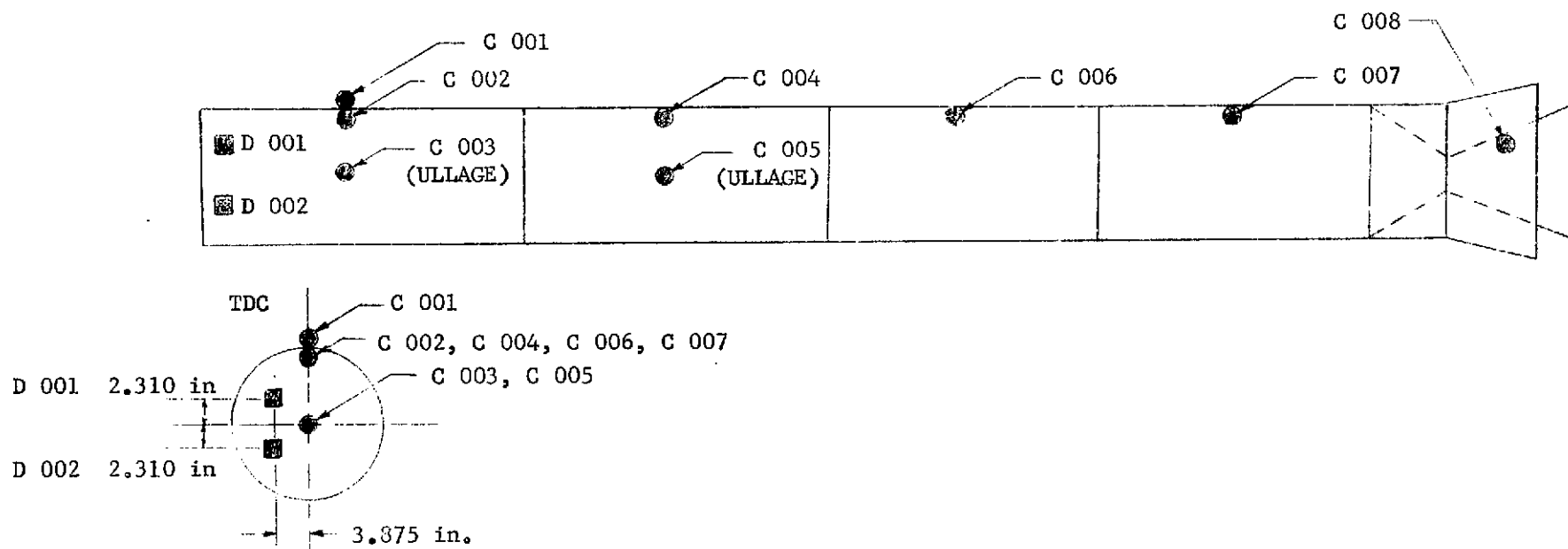


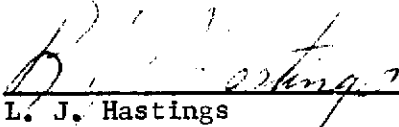
FIGURE 5. 12.5-INCH THERMAL SRB MODEL PRESSURE AND TEMPERATURE LOCATIONS

APPROVAL

DATA BOOK FOR 12.5-INCH DIAMETER SOLID ROCKET BOOSTER
THERMAL MODEL WATER IMPACT TEST PROGRAM

by
S. L. Allums

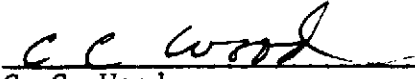
The information in this report has been reviewed and approved
for technical accuracy.



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APPENDIX A

IMPACT, PENETRATION AND INITIAL TEMPERATURE DATA

12.5-INCH THERMAL MODEL SRB

TABLE 1. IMPACT PARAMETERS

TEST NO.	IMPACT VELOCITY ft/sec	HORIZONTAL VELOCITY ft/sec	IMPACT ANGLE degrees	ANGLE AT MAXIMUM PENETRATION degrees	MAXIMUM PENETRATION		AVERAGE WALL TEMPERATURE °F	ULLAGE TEMPERATURE °F
					ft	TIME sec		
1	5.15	0	0.50	4.899	4.048	1.040		
2	15.70	0	0.10	3.999	4.775	0.684		
3	30.24	1.23	-0.10	1.0	5.970	0.624		
4	30.88	0	-9.20	-16.69	5.839	0.280		
5	15.74	0	10.70	32.49	4.348	0.592		
6	5.24	0	11.90	36.09	3.799	0.791		
7	3.06	0	19.60	44.69	3.263	0.764		
8	15.12	0	19.70	46.79	3.496	0.548		
9	30.88	0	19.80	47.19	4.327	0.384		
11	30.24	-0.99	0.90	0.90	6.536	0.560	213	245
12	16.02	0	0.70	0.70	5.498	0.812	180	198
13	4.99	0	-0.59	0.59	4.084	0.836	162	183
14	15.67	0	19.10	47.39	3.817	0.528	212	240
15	6.82	0	19.20	46.39	3.234	0.684	166	205
16	30.18	0	18.20	49.19	4.472	0.412	195	245
17	5.40	0	11.60	41.79	4.188	0.90	165	194
18	15.28	0	11.00	37.99	4.522	0.676	185	204
19	30.18	0	12.0	43.39	5.799	0.628	187	212
20	4.34	0	-- NO DATA ----		4.52	1.04	190	236
23	15.15	0	0.30	1.39	5.541	0.884	304	330
24	4.99	0	0.10	0.10	4.183	0.968	283	319

TABLE 1. IMPACT PARAMETERS (Cont'd)

TEST NO.	IMPACT VELOCITY ft/sec	HORIZONTAL VELOCITY ft/sec	IMPACT ANGLE degrees	ANGLE AT MAXIMUM PENETRATION degrees	MAXIMUM PENETRATION		AVERAGE WALL TEMPERATURE °F
					ft	TIME / sec	
25	4.34	0	-0.10	1.30	3.932	/ 0.940	266 / 280
26	30.40	0	0.40	3.89	6.288	/ 0.608	279 / 305
27	30.50	0	0.80	3.89	7.344	/ 0.816	258 / 300
28	30.30	0	0.60	2.99	6.992	/ 0.708	298 / 355
29	15.25	-----	NO DATA	-----	4.92	/ 0.708	283 / 340
31	30.11	0	20.10	27.89	2.40	/ 0.196	325 / 377
32	15.18	0	0.70	0.79	4.510	/ 0.615	187 / 183
33	4.05	0	-0.30	6.90	4.223	/ 1.096	224 / 253
34	14.80	0	0.80	0.79	5.069	/ 0.776	353 / 408
35	14.83	0	-0.30	0.80	5.126	/ 0.780	404 / 472
37	15.06	0	18.70	46.49	3.447	/ 0.547	396 / 458
38	14.77	0	0.20	0.50	5.141	/ 0.748	399 / 447
39	14.80	0	0.10	0.29	5.138	/ 0.764	455 / 536
40	23.58	0	0.70	2.69	6.274	/ 0.748	312 / 357
42	23.81	-----	NO DATA	-----	7.25	/ .708	446 / 521
43	23.81	0	18.399	52.89	4.228	/ 0.528	372 / 413
44	35.97	0	18.70	26.29	3.332	/ 0.164	277 / 320
45	36.03	1.13	1.70	4.89	7.635	/ 0.676	273 / 342

APPENDIX B

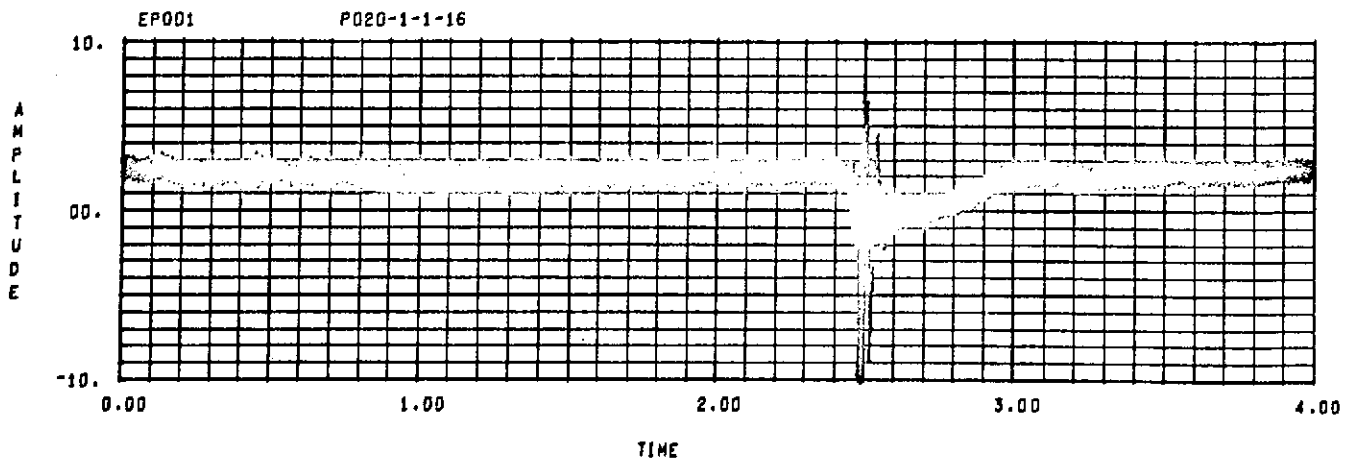
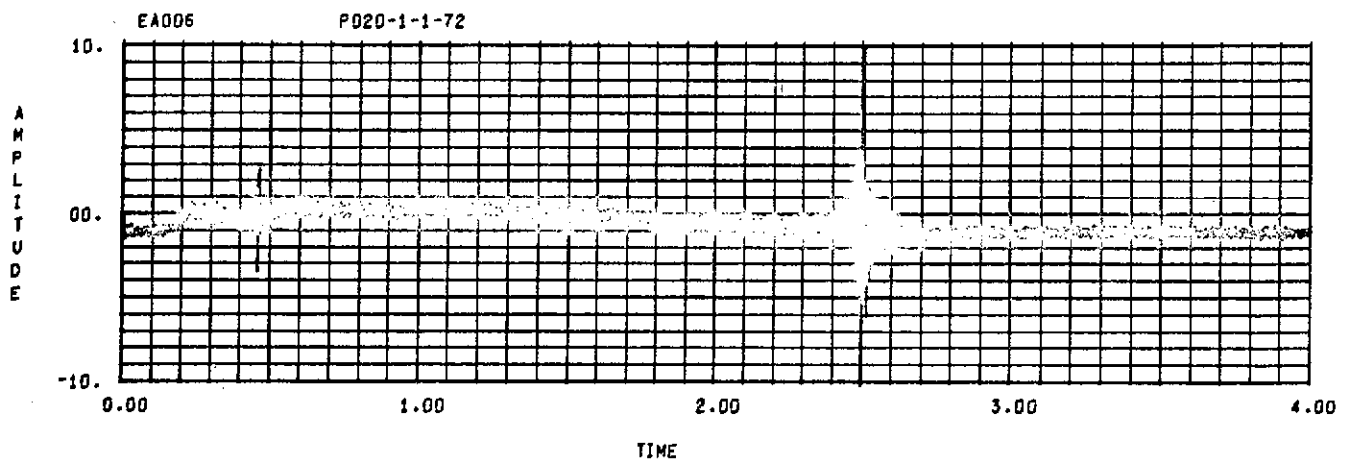
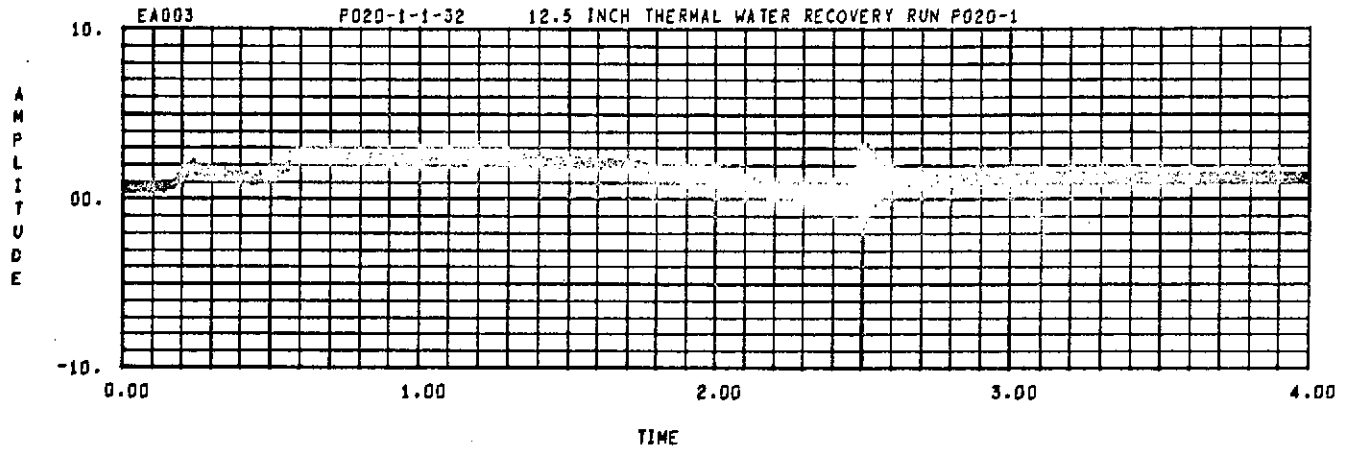
ACCELERATION, PRESSURE, AND TEMPERATURE DATA

APPENDIX B

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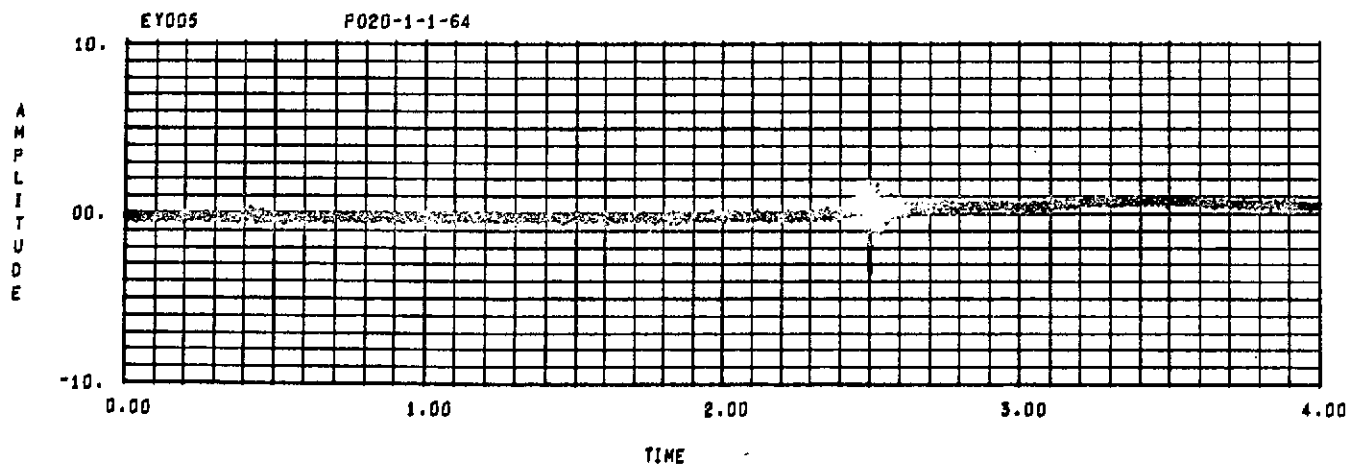
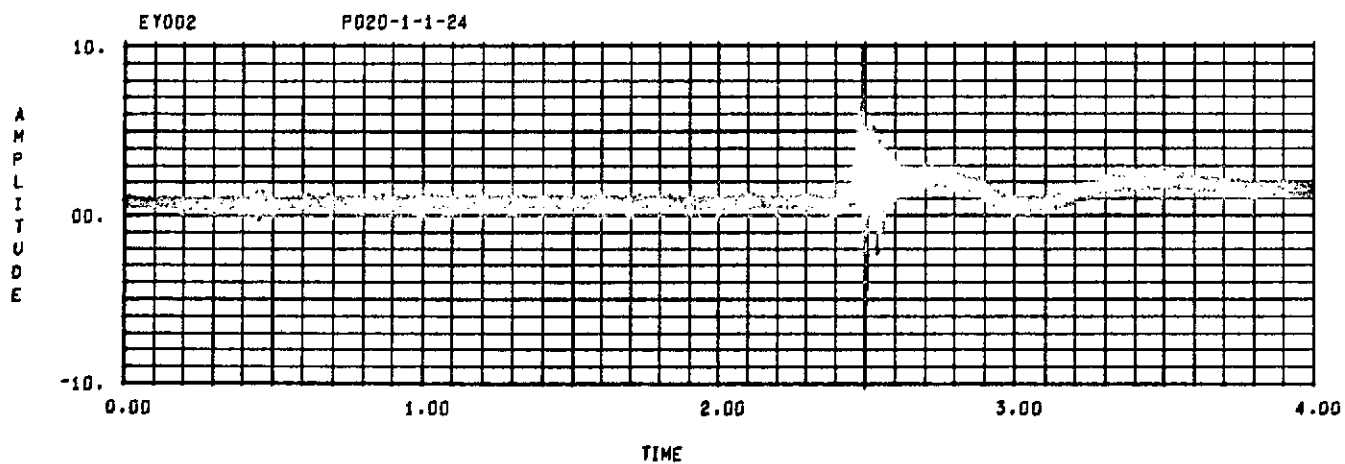
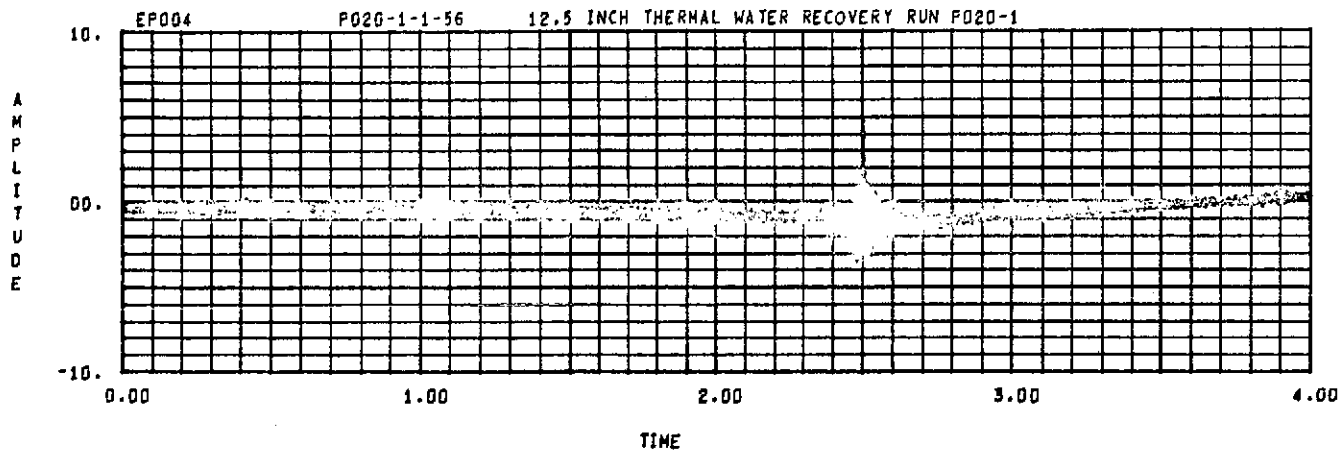
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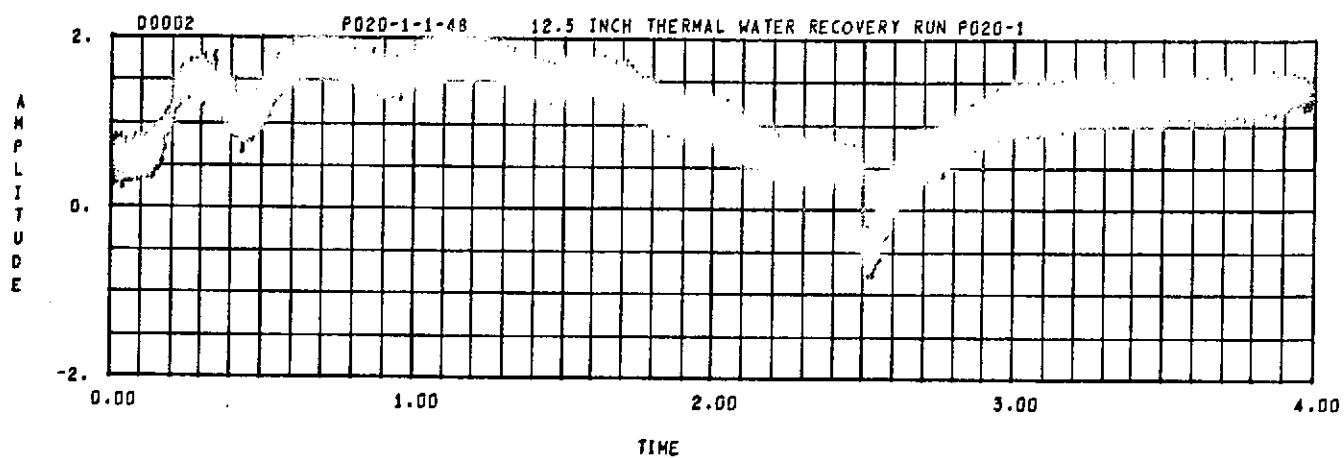
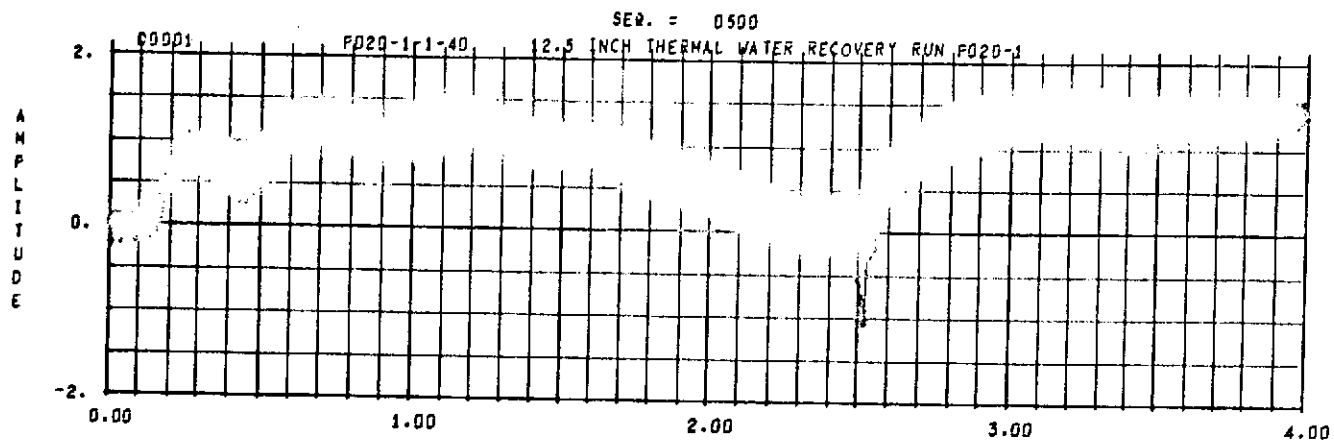
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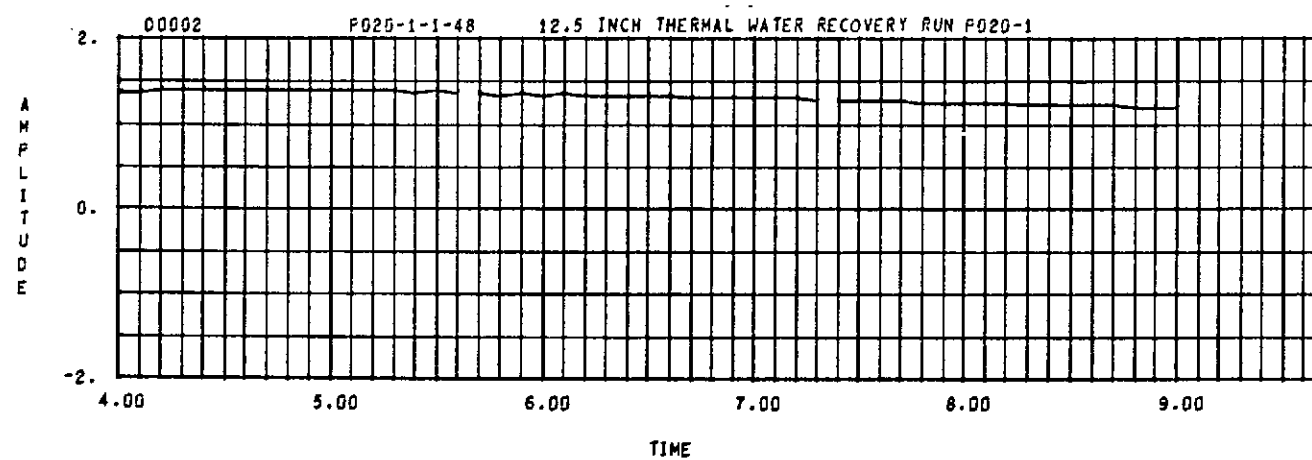
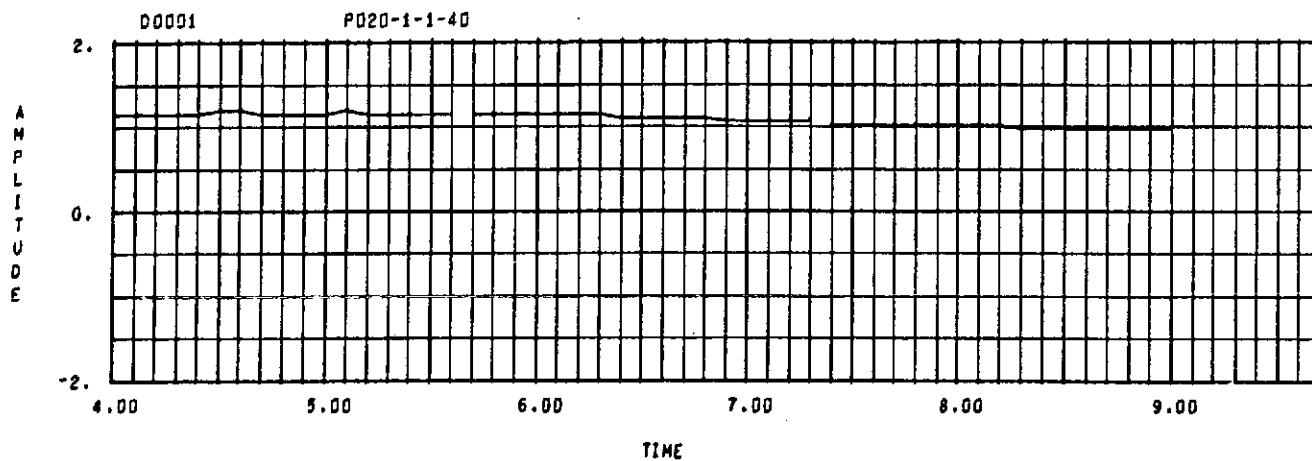


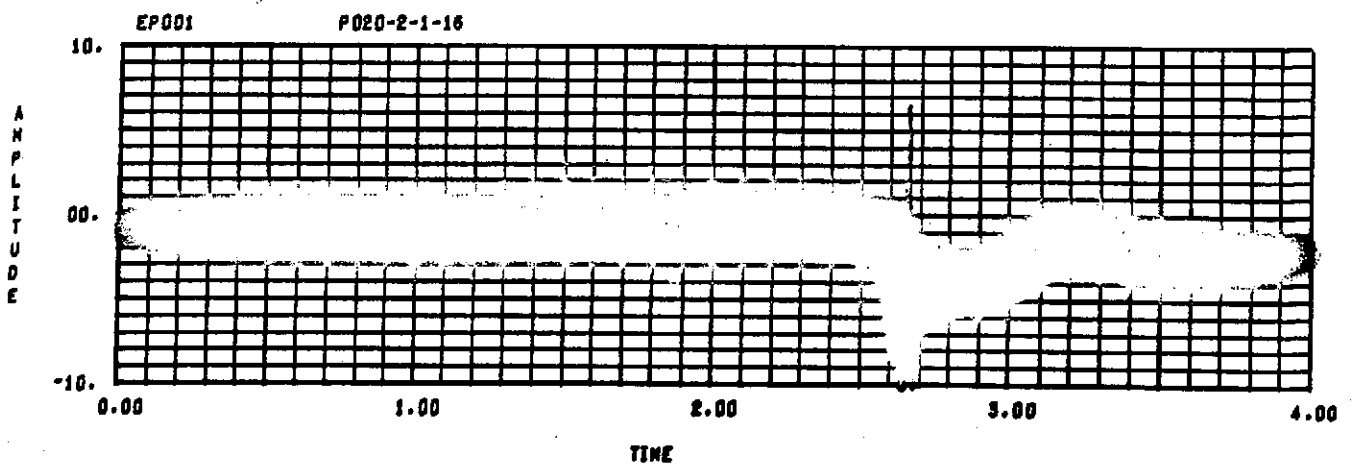
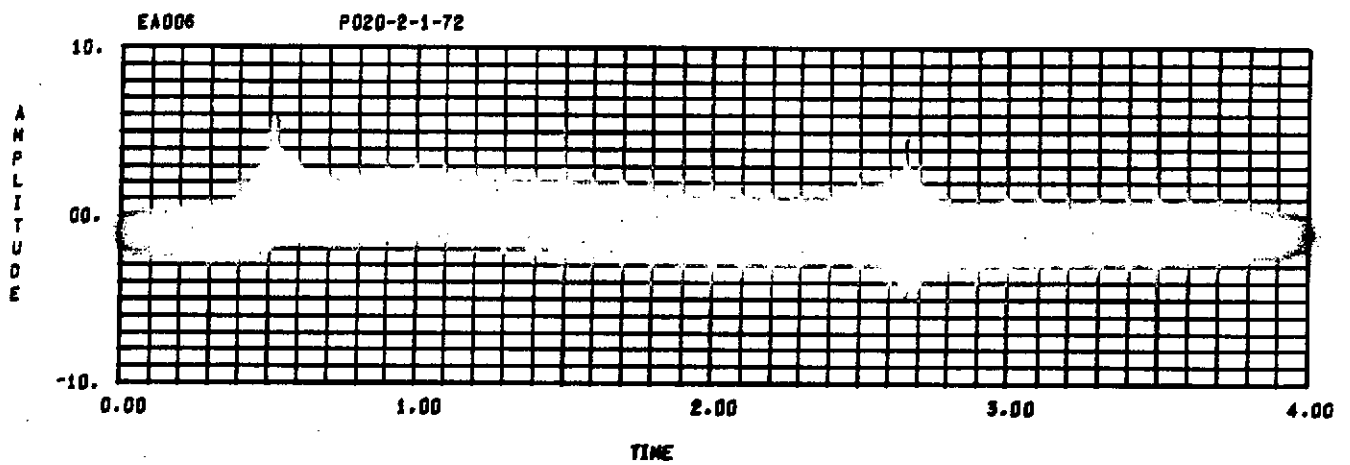
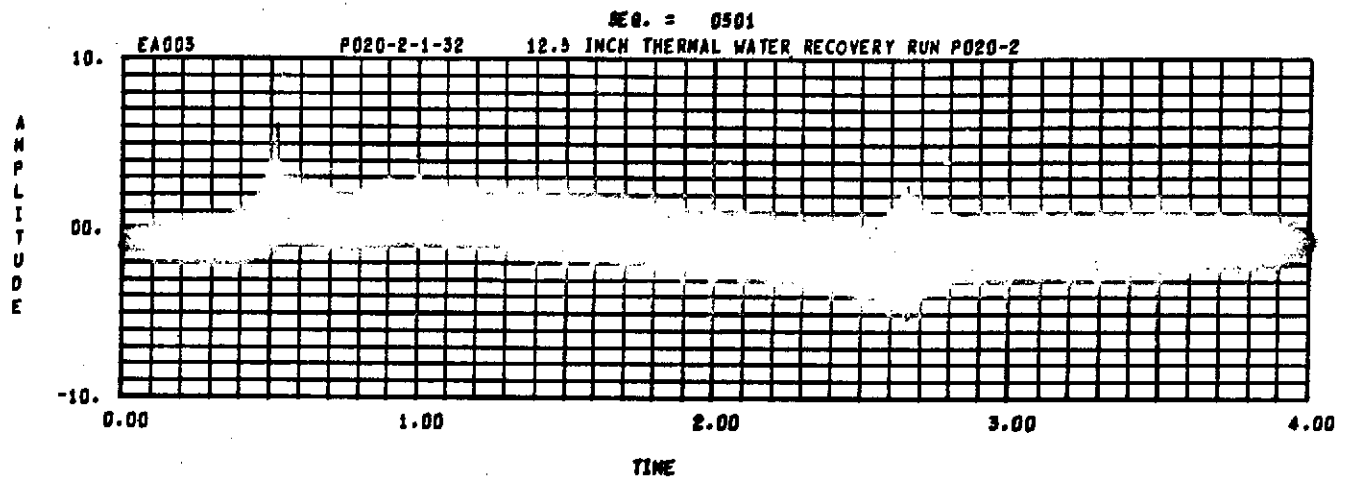
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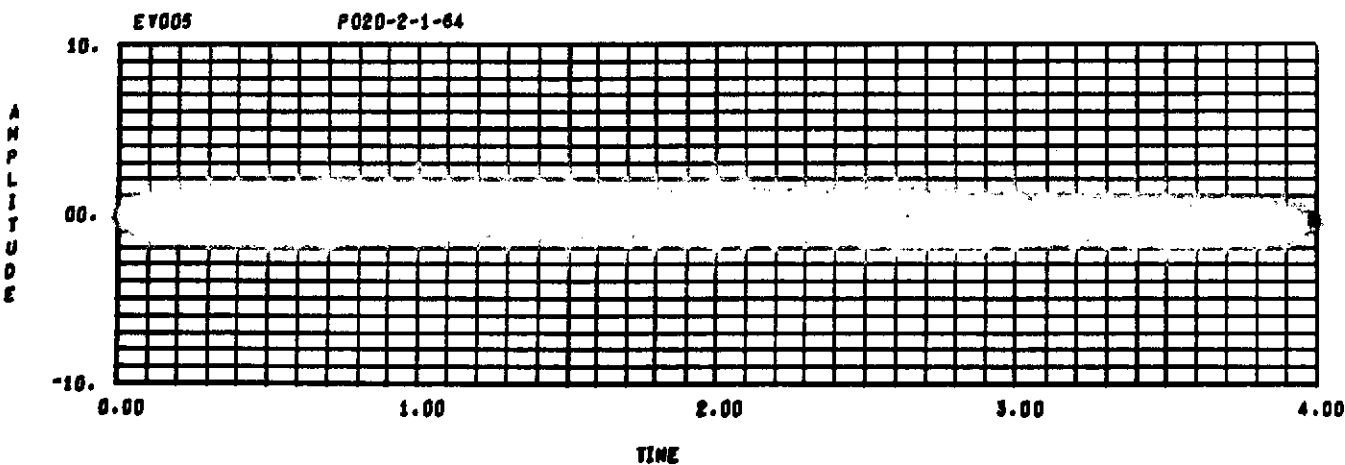
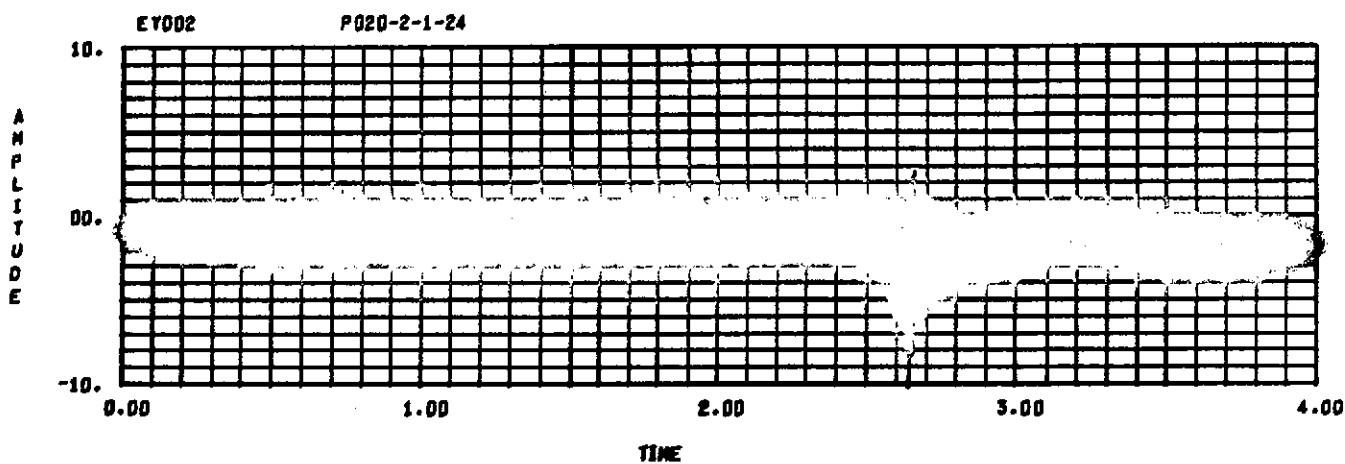
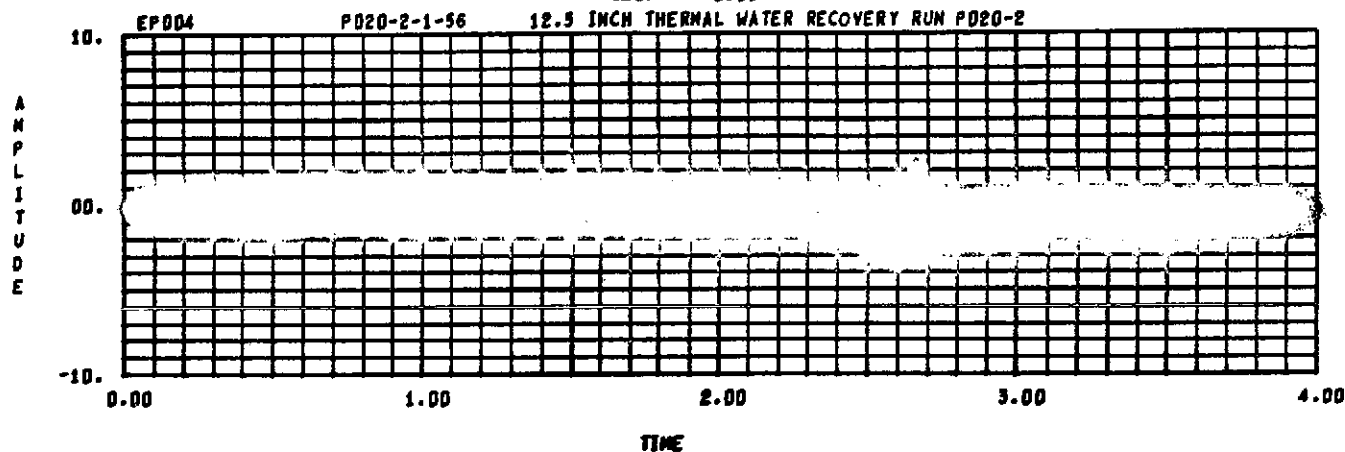


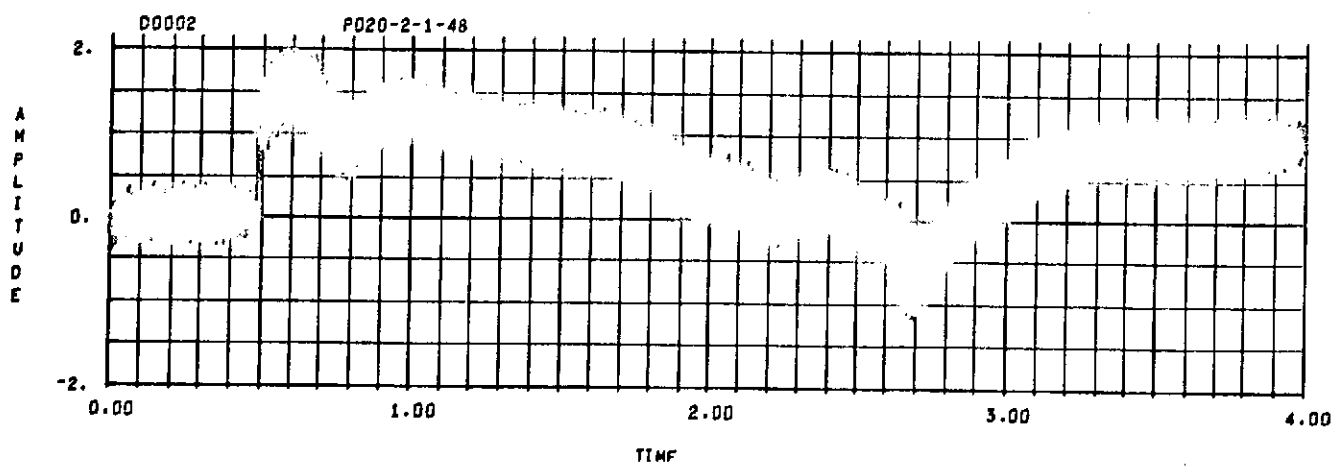
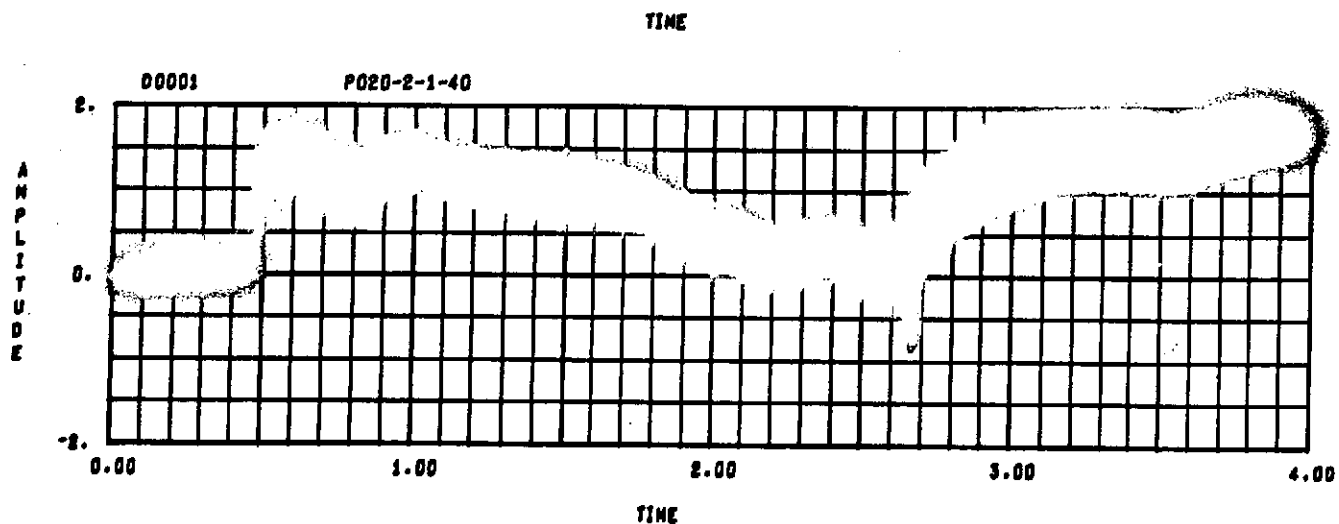


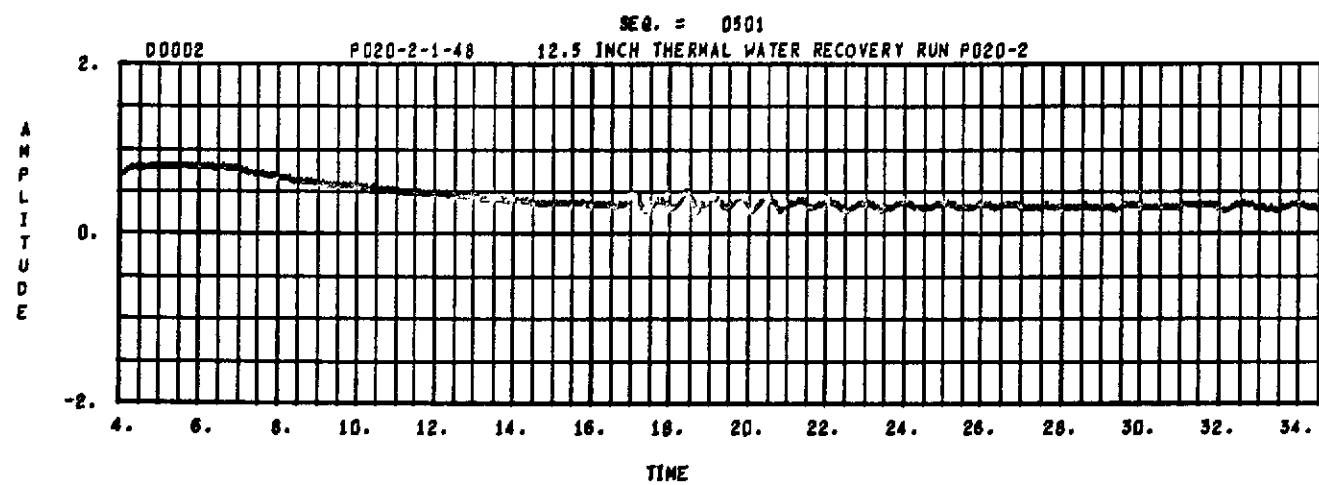
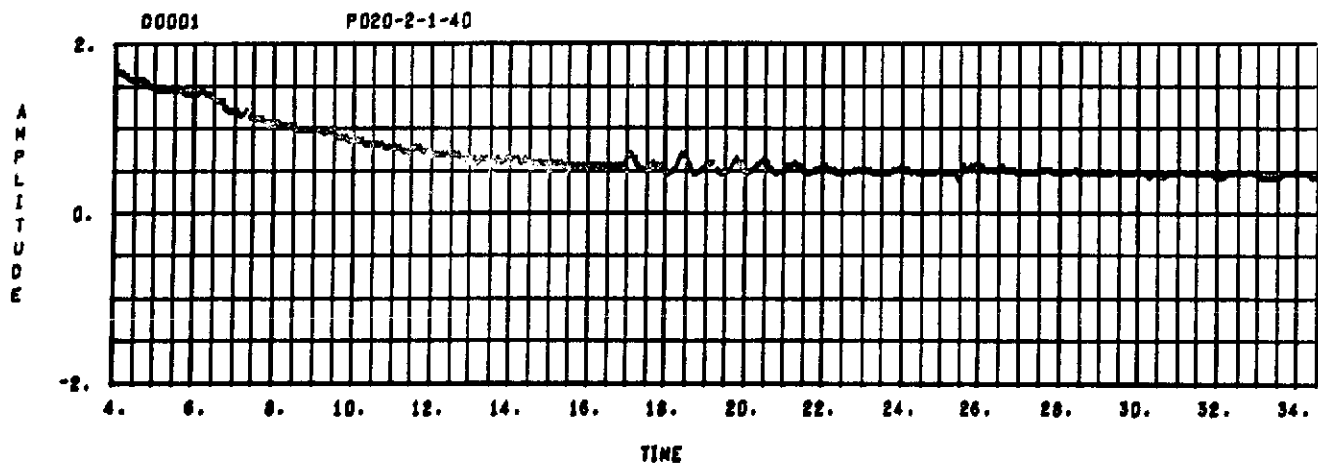


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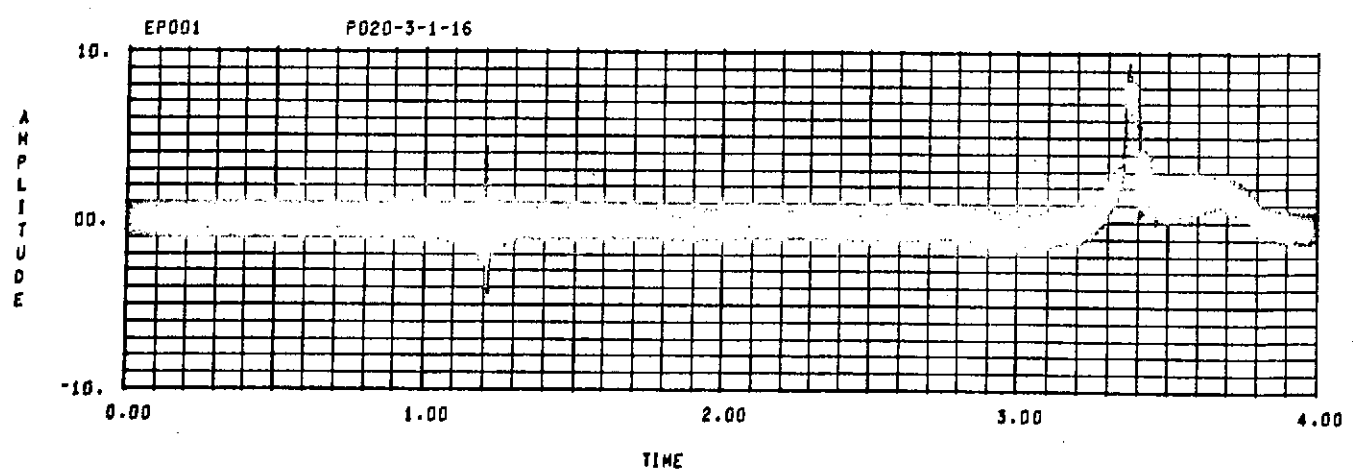
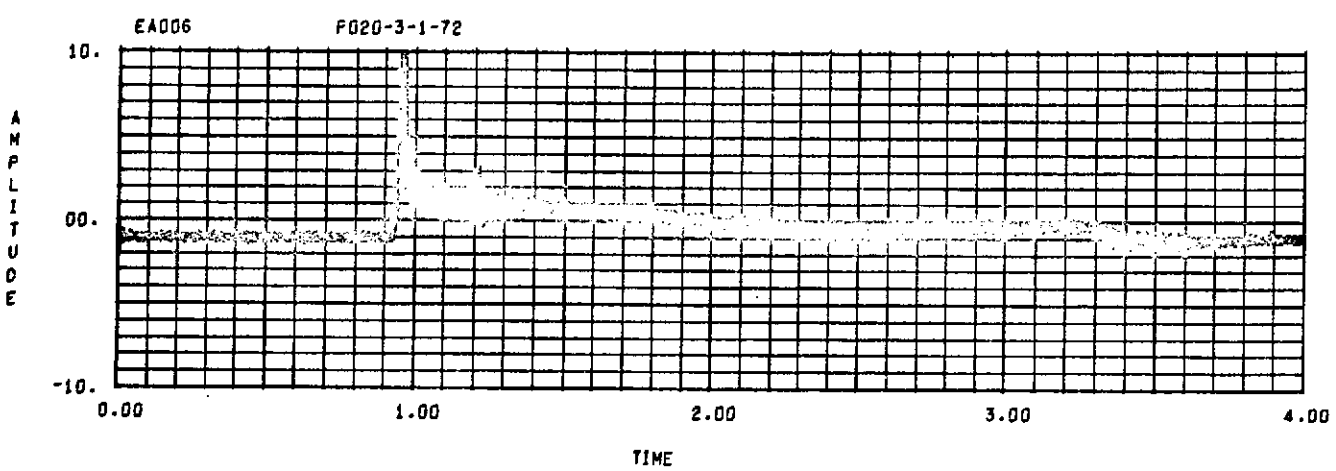
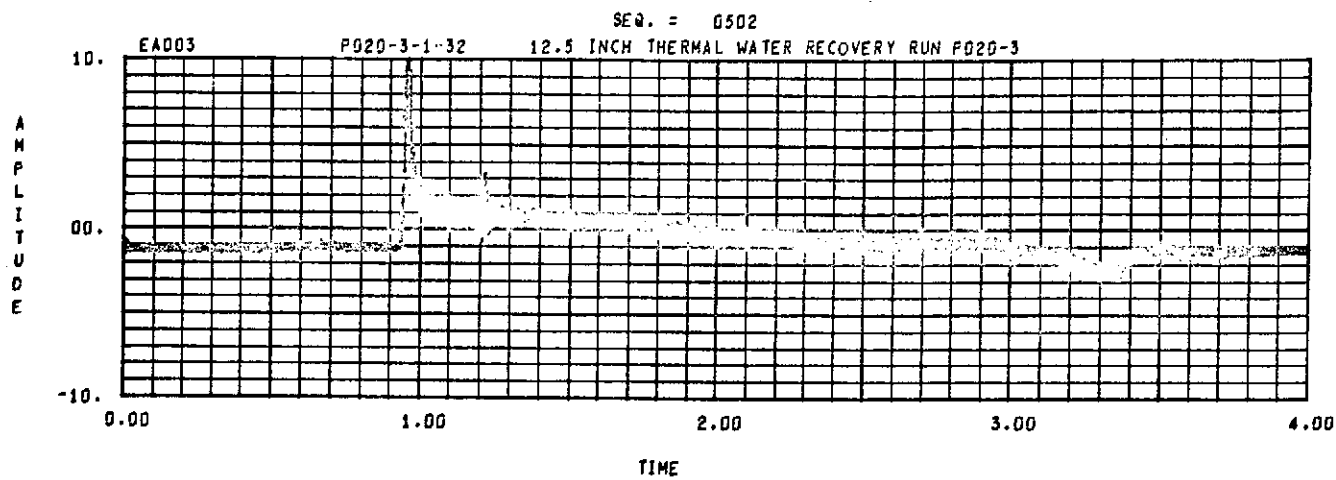
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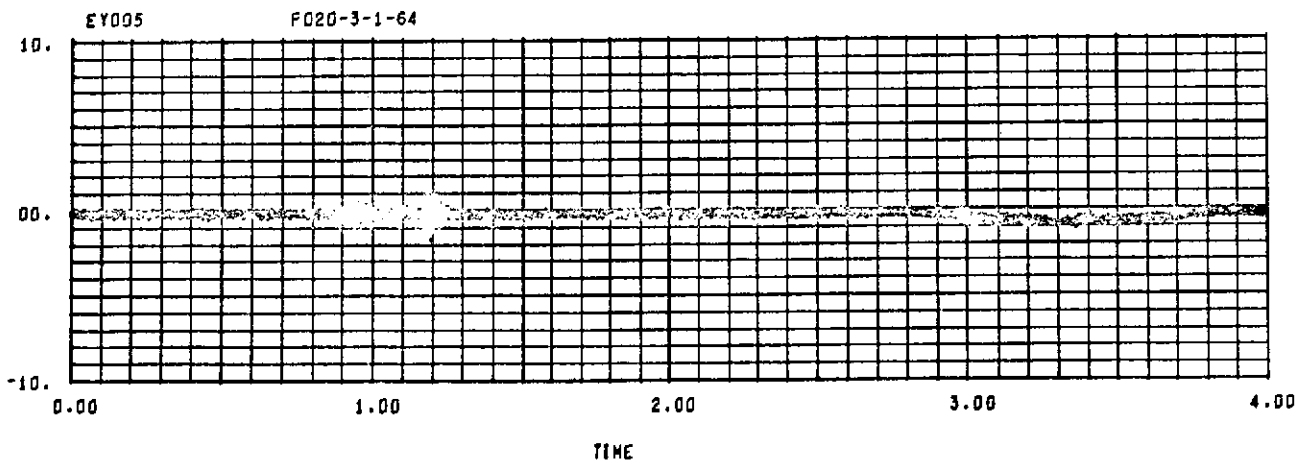
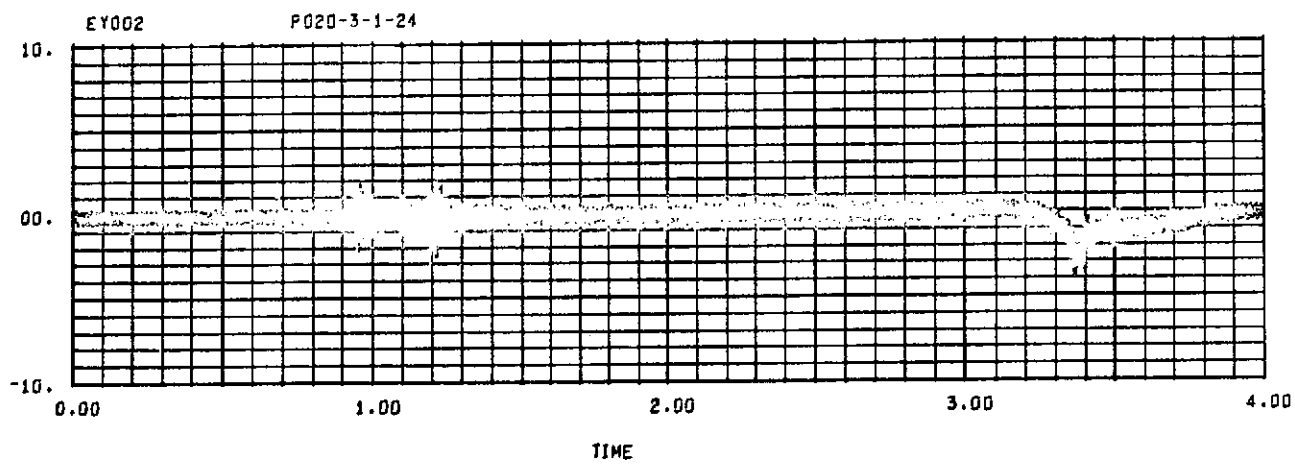
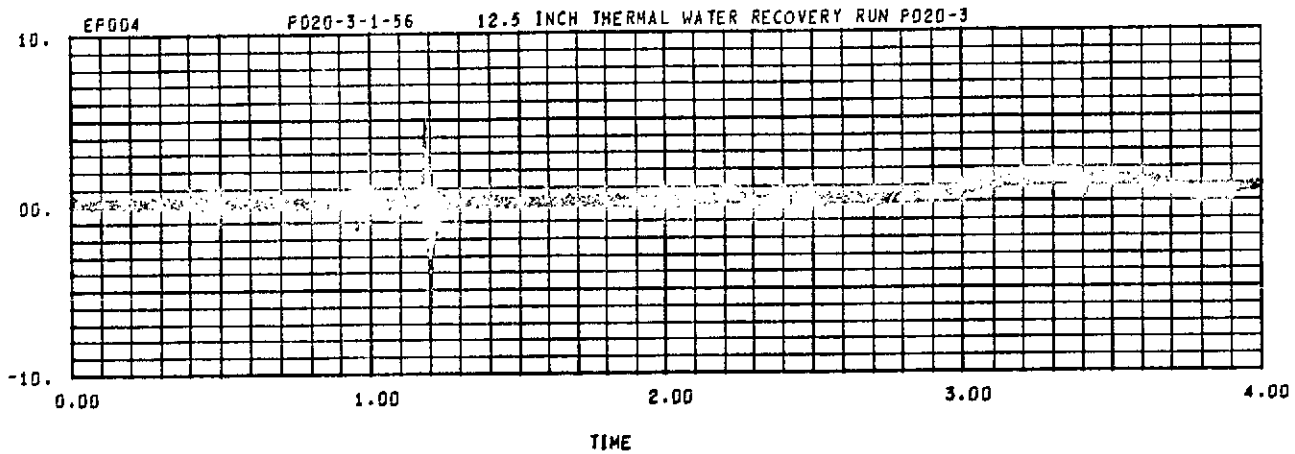


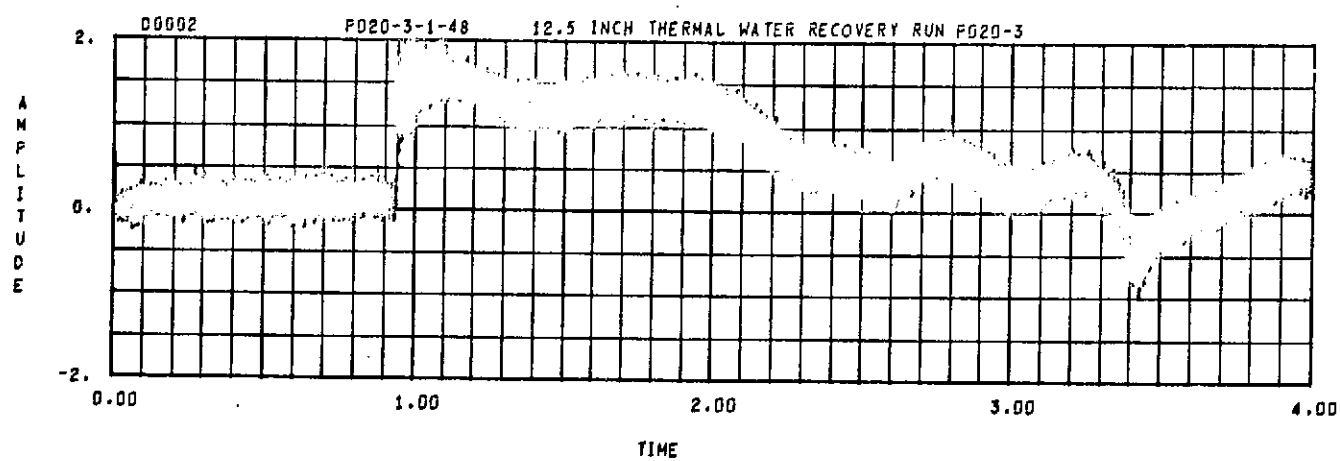
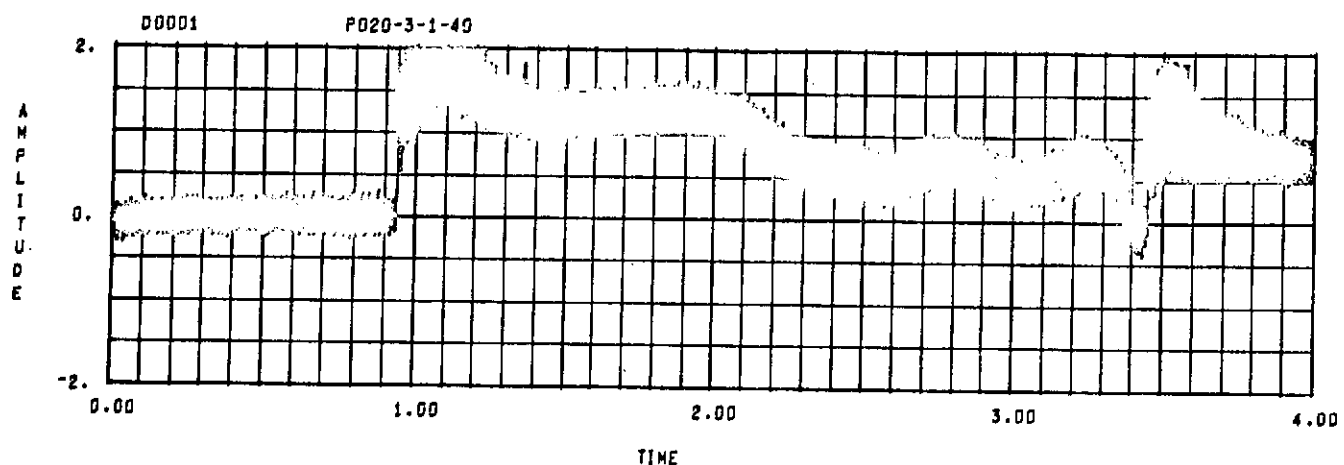


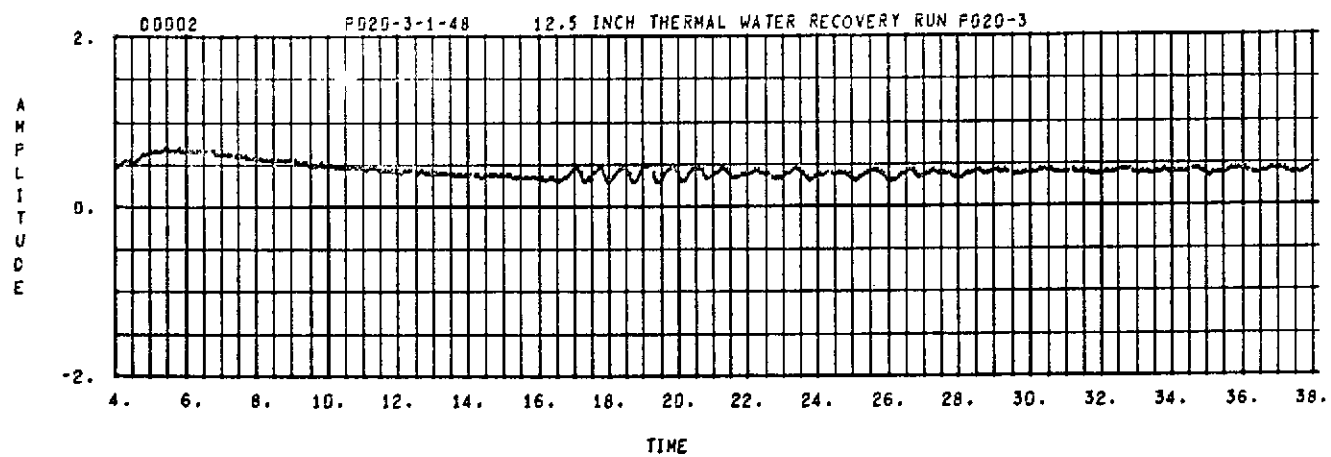
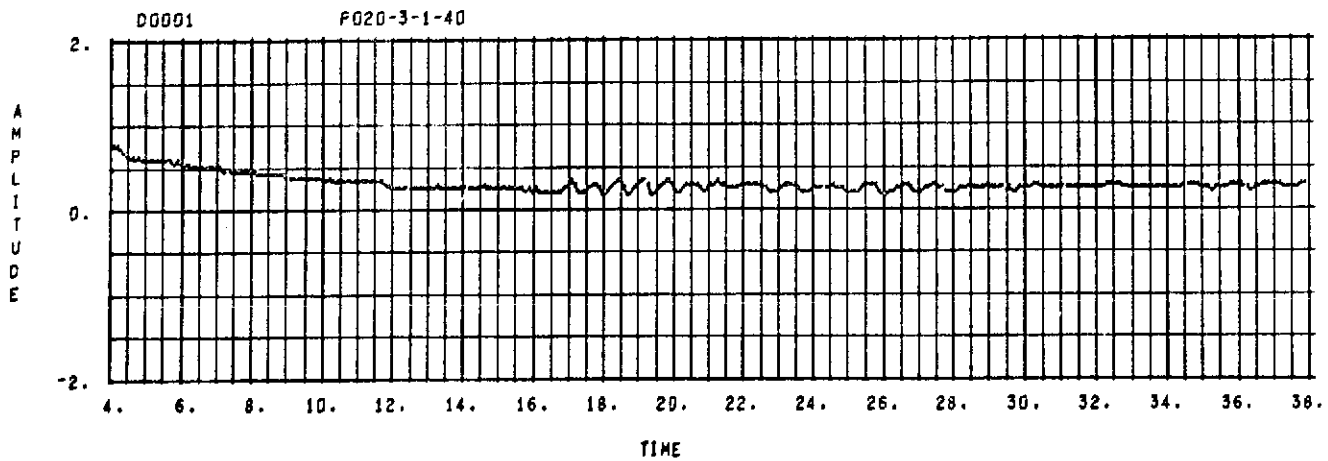
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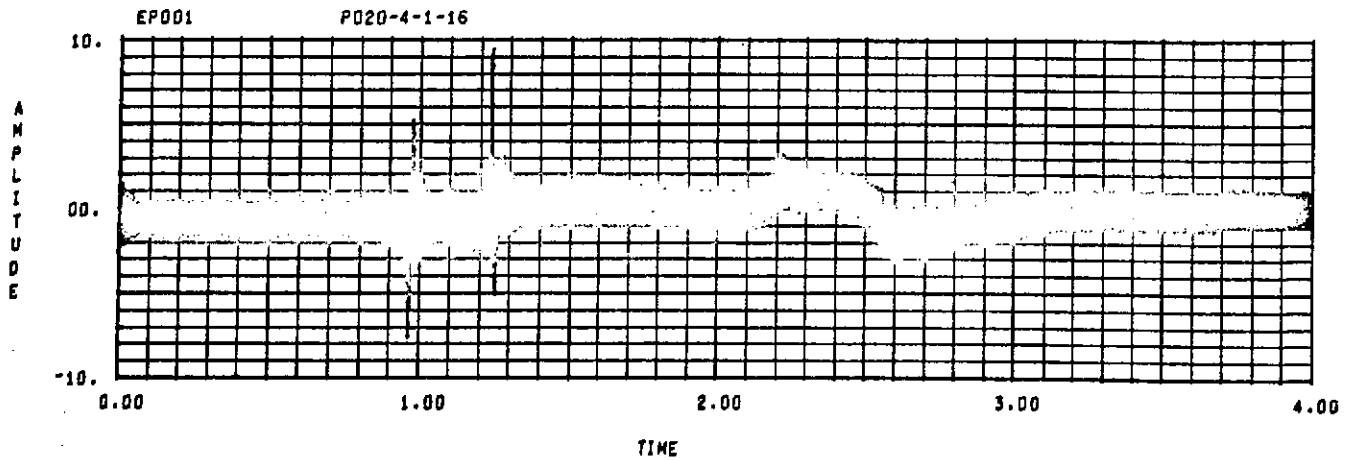
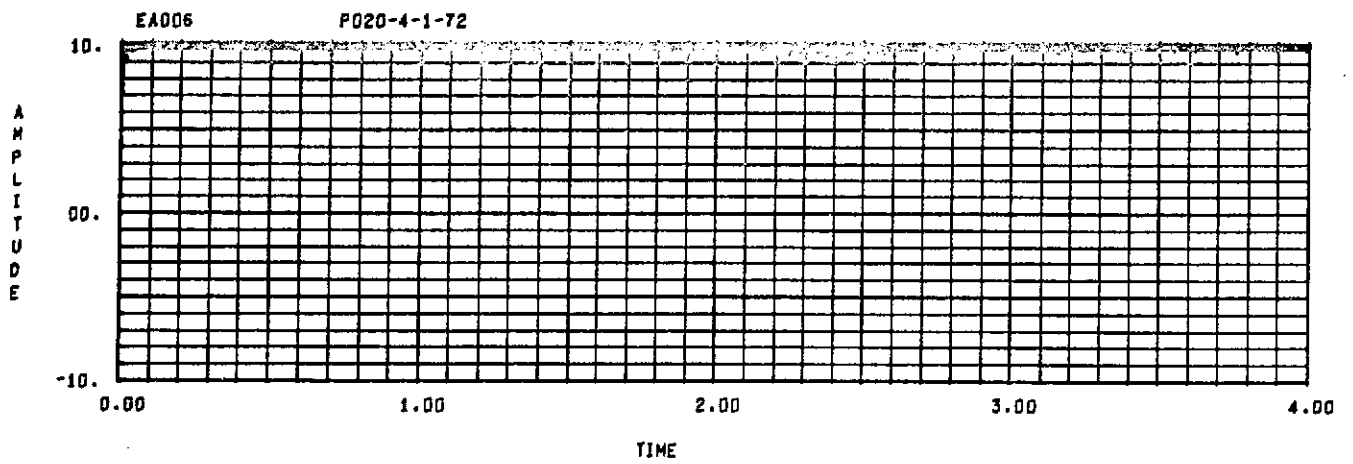
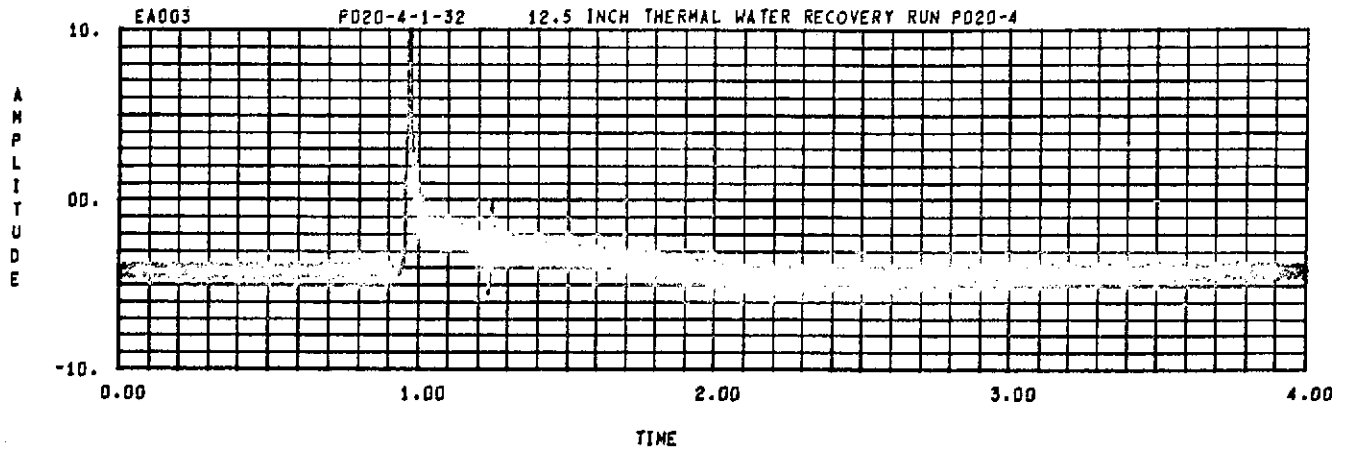






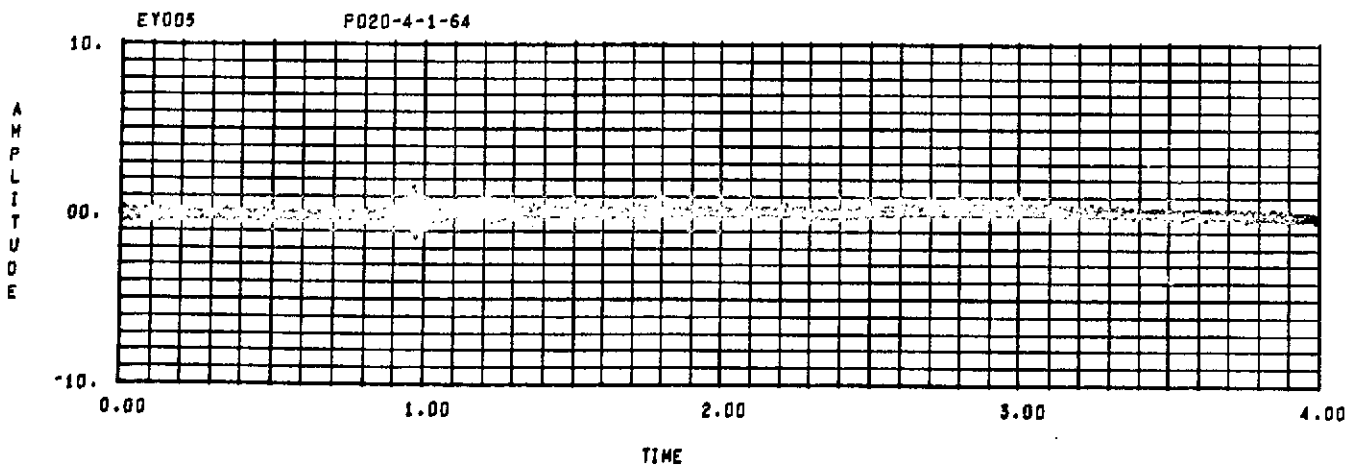
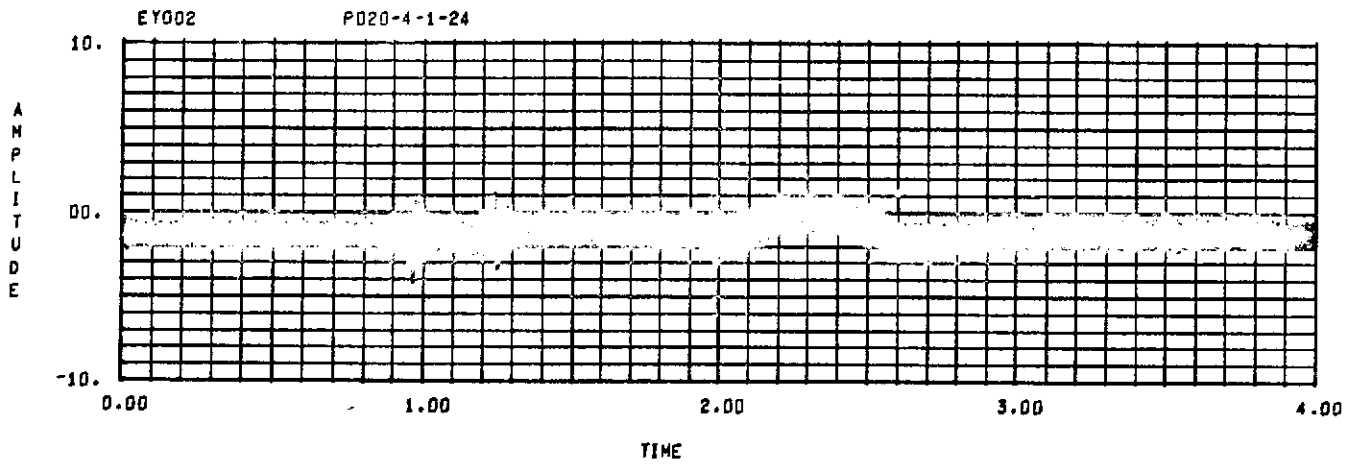
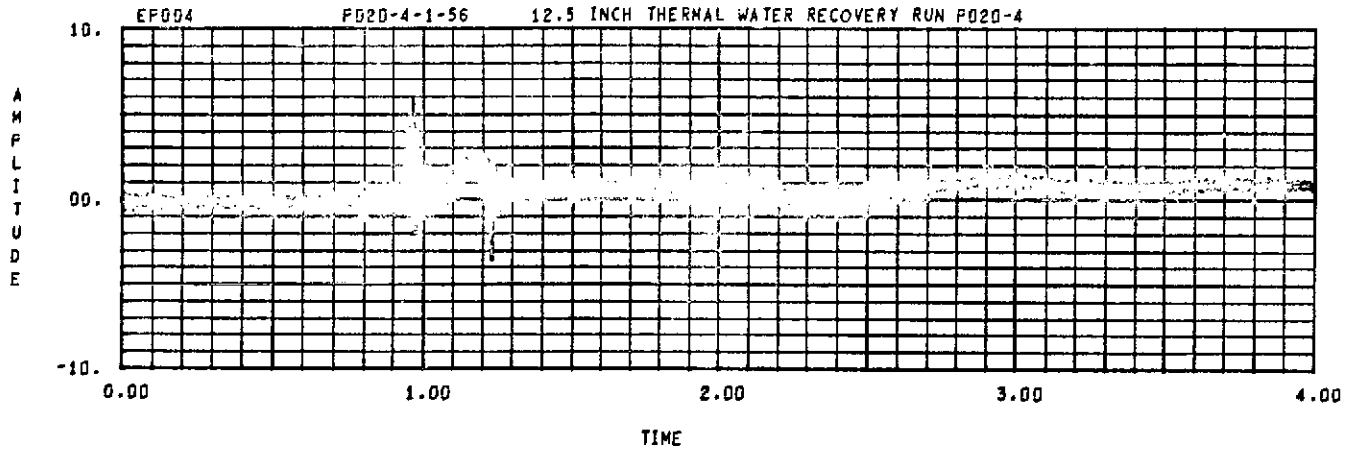
SEQ. = 0503

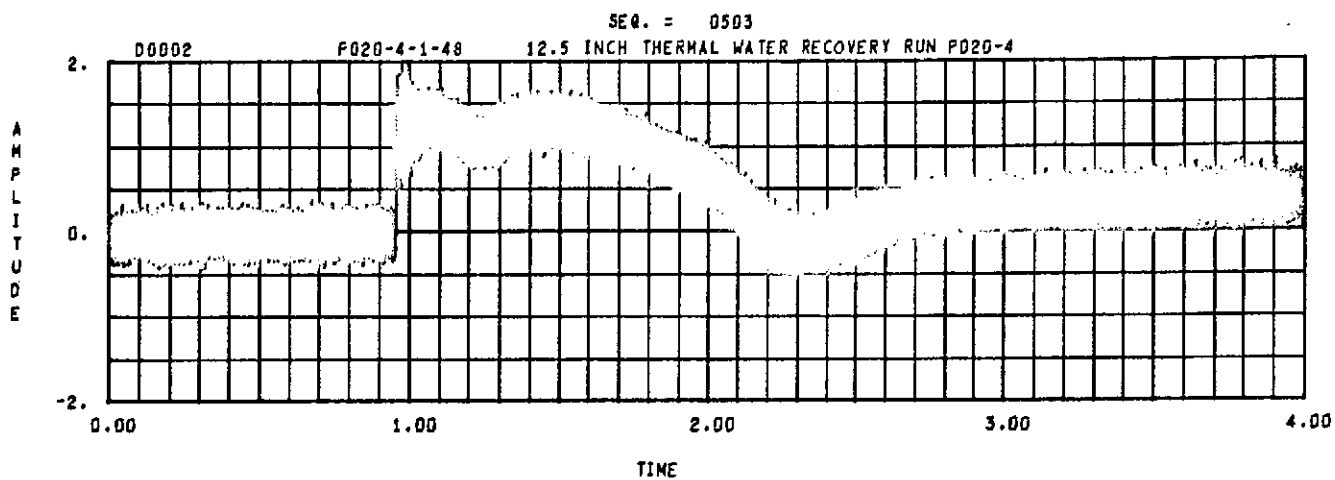
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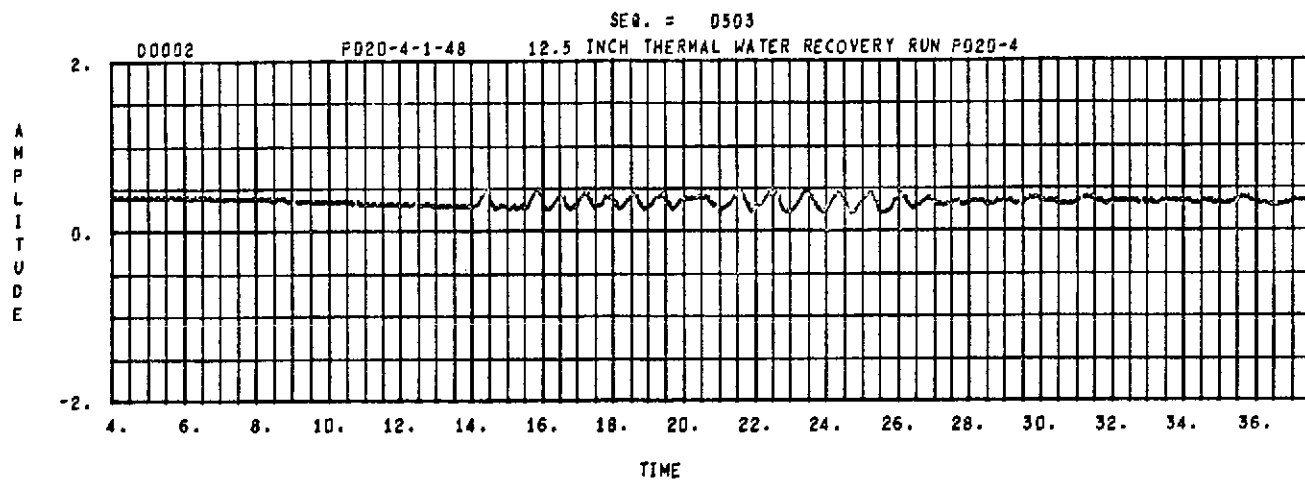


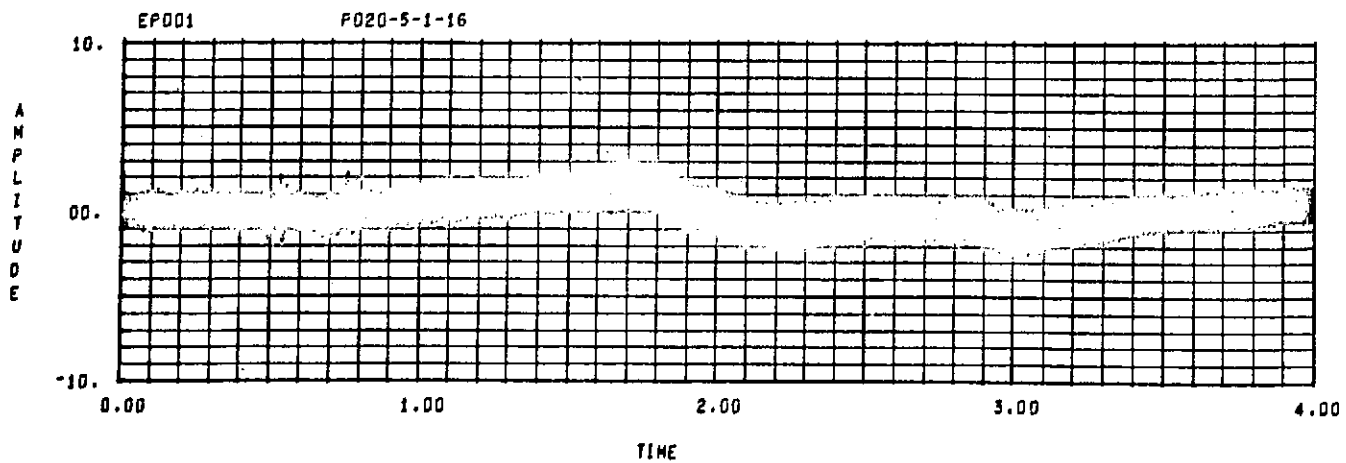
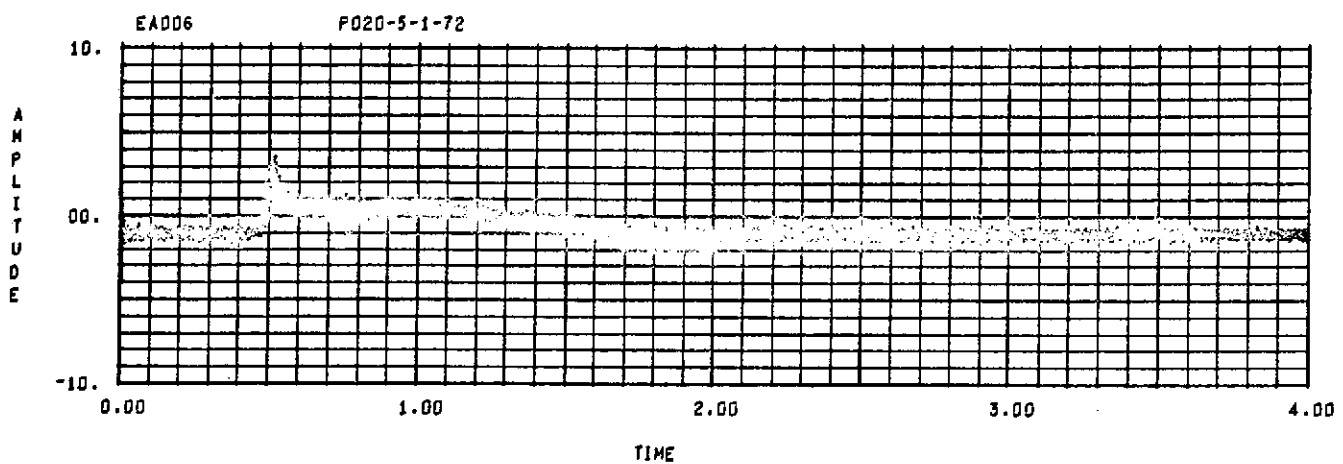
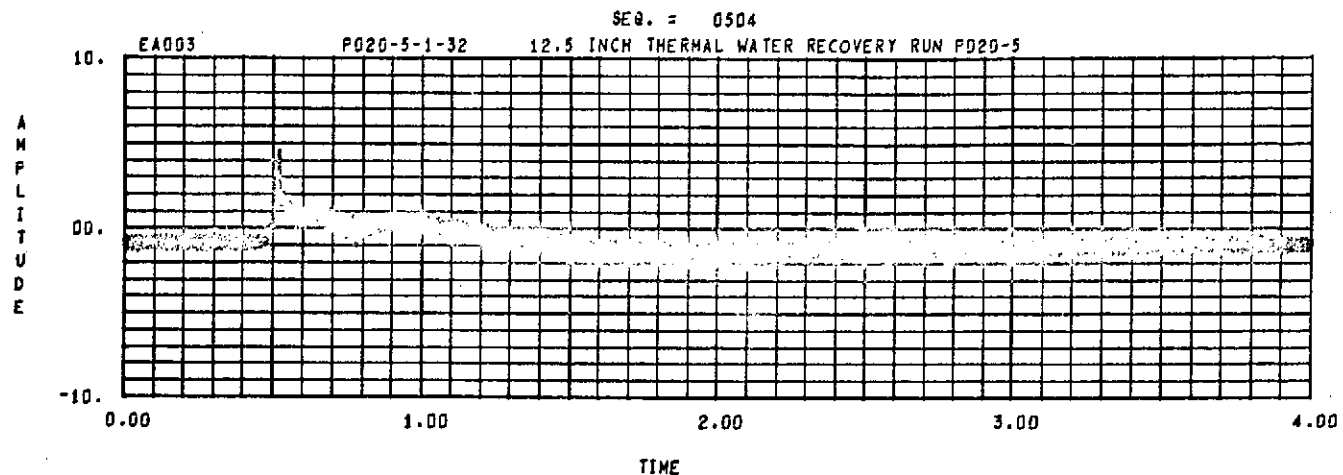
SEQ. = 0503

2



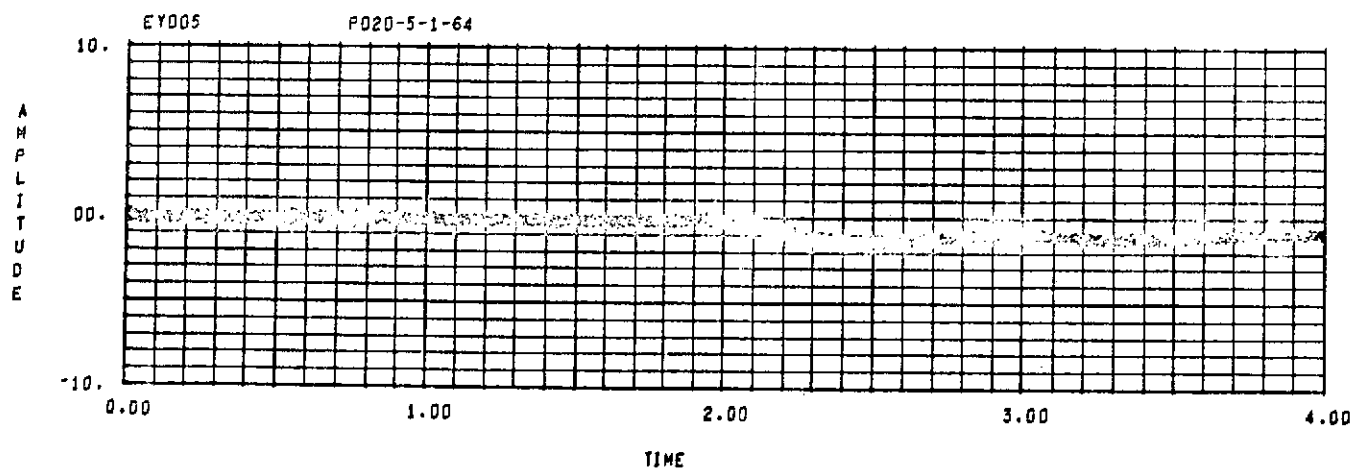
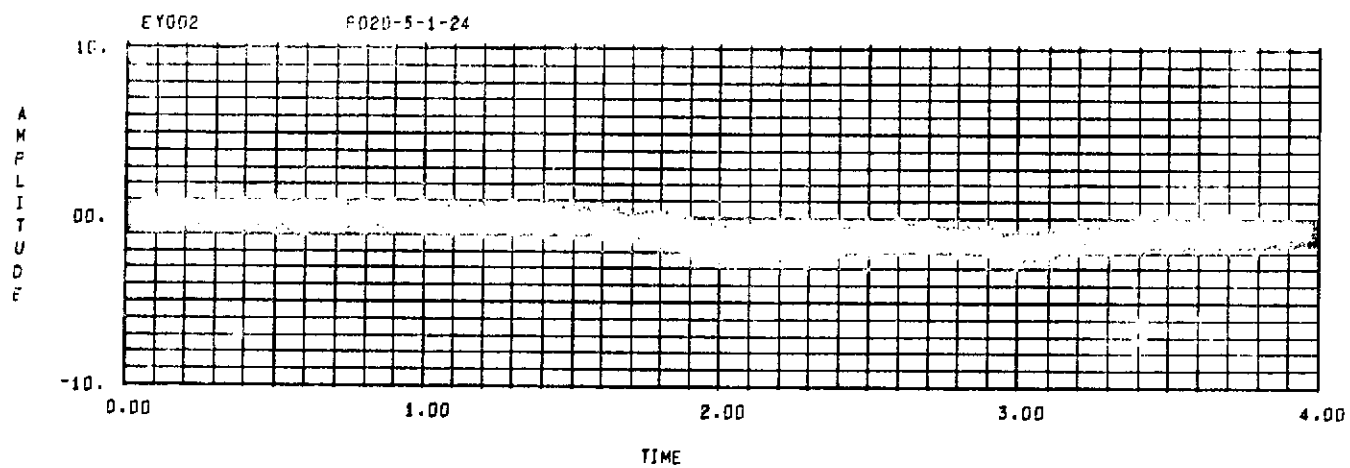
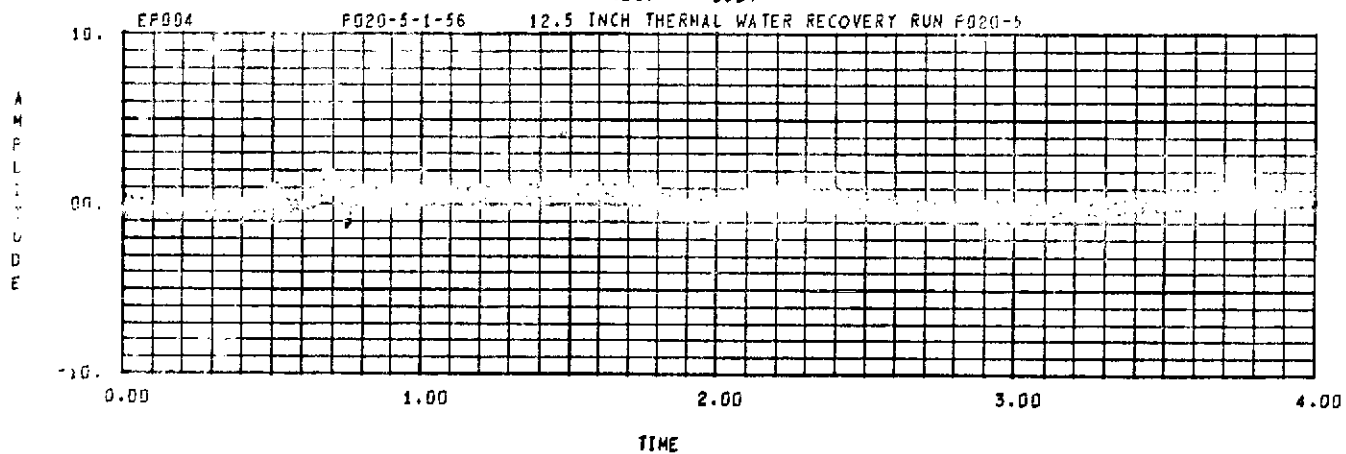


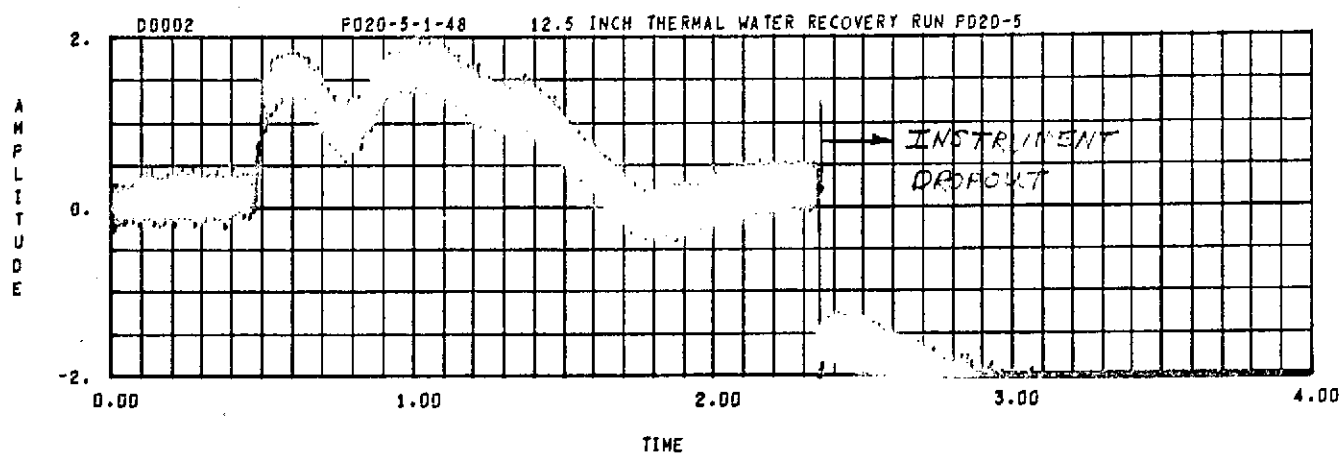
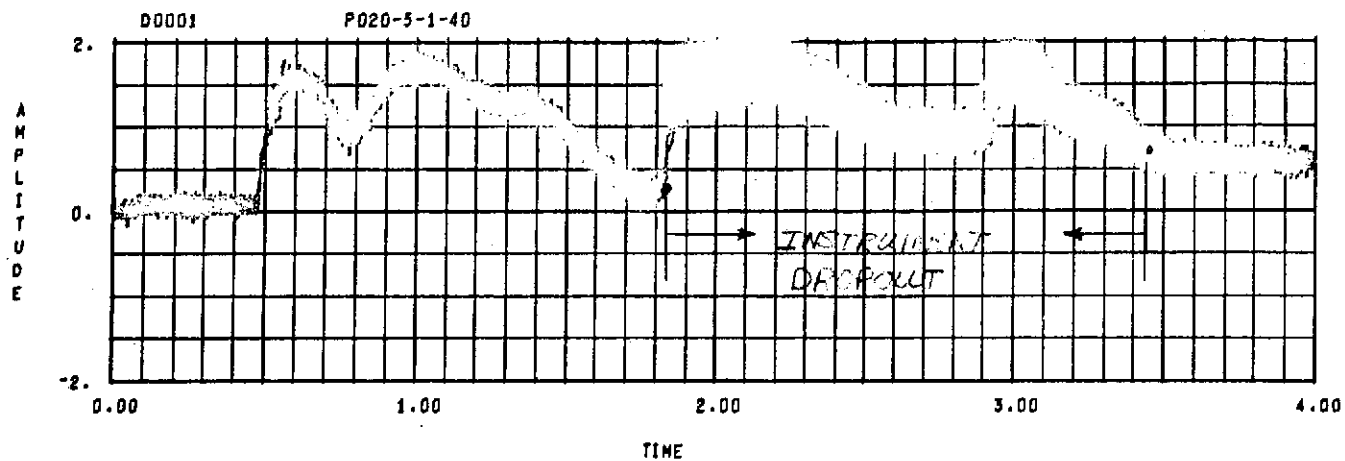


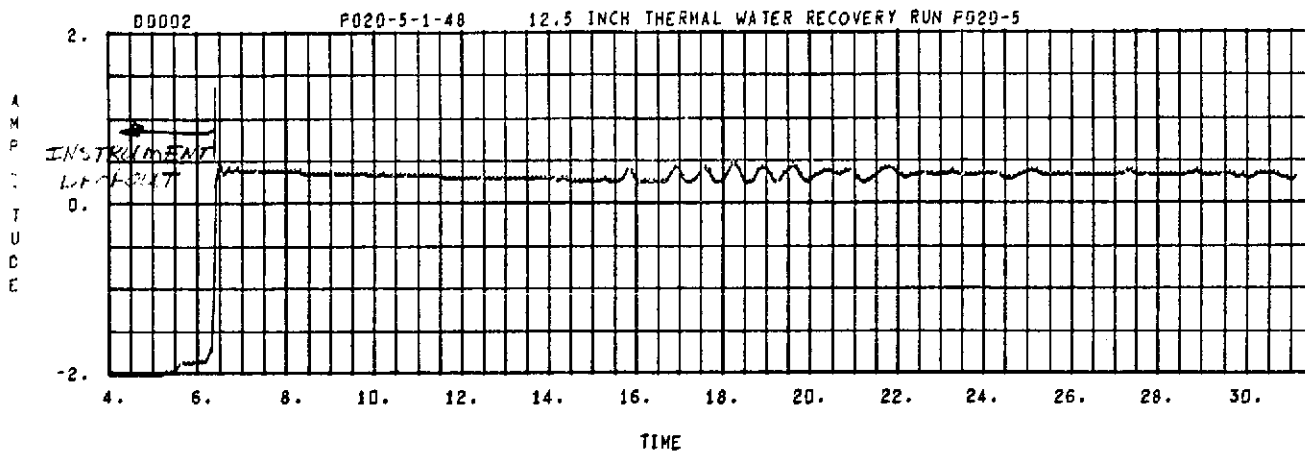


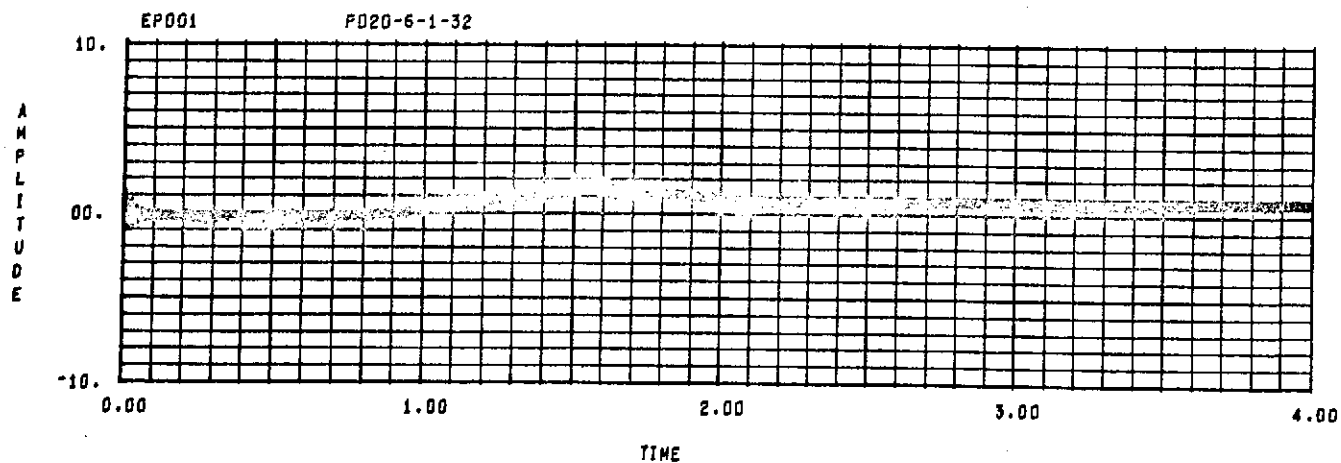
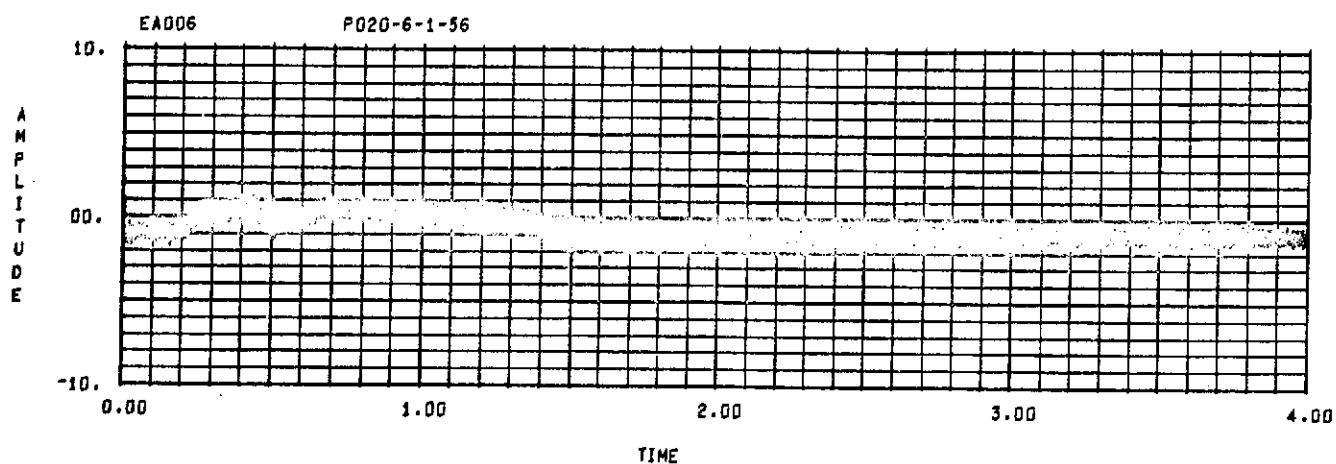
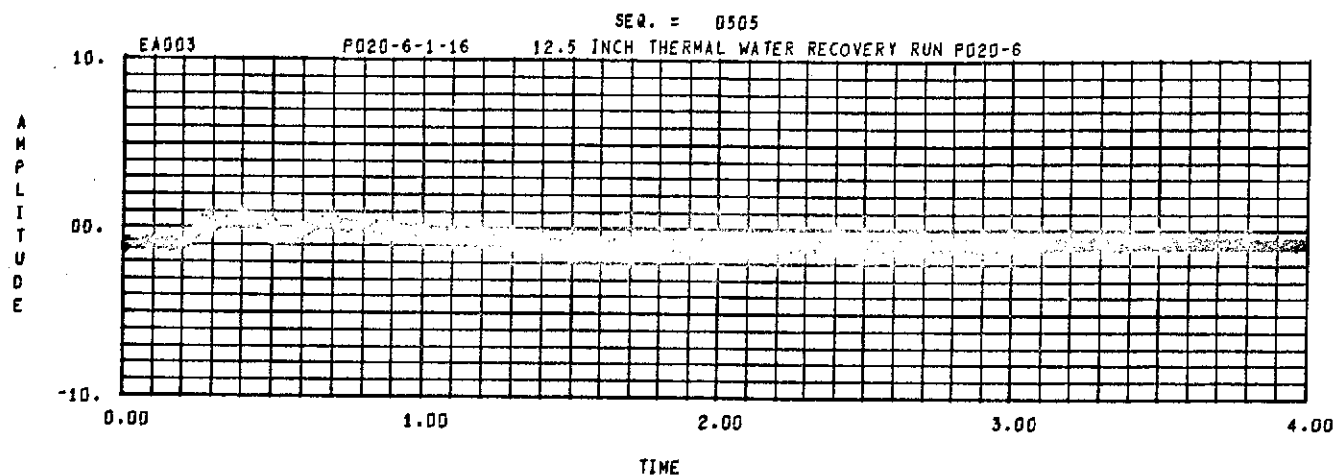
SEQ. = 0504

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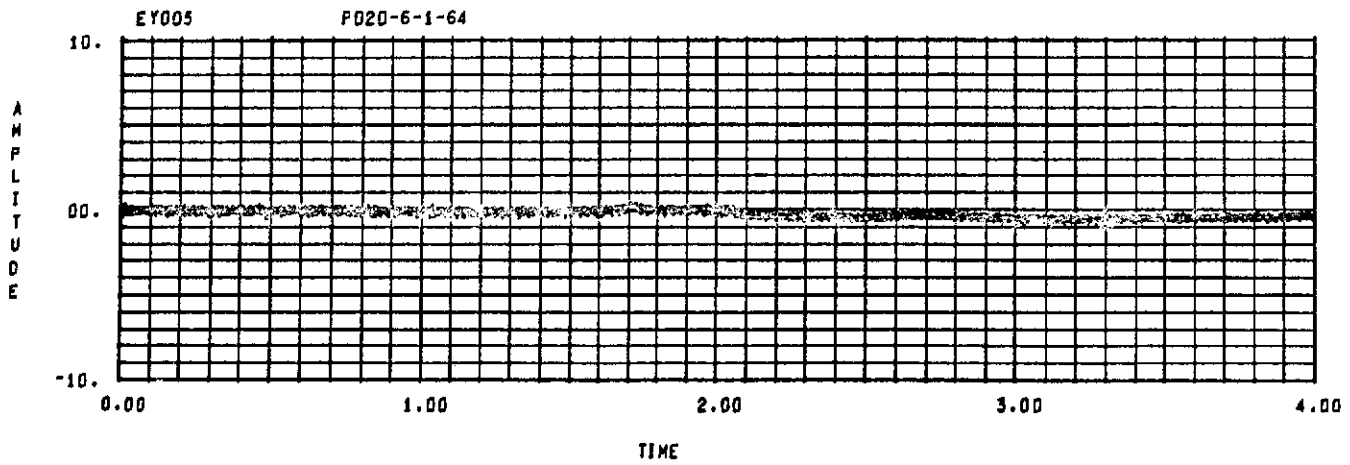
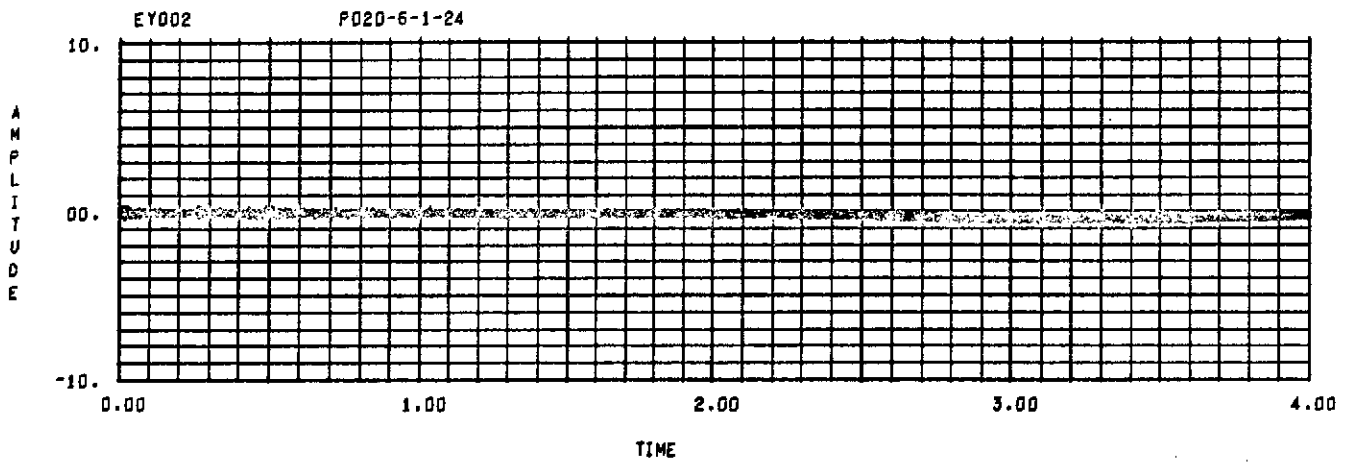
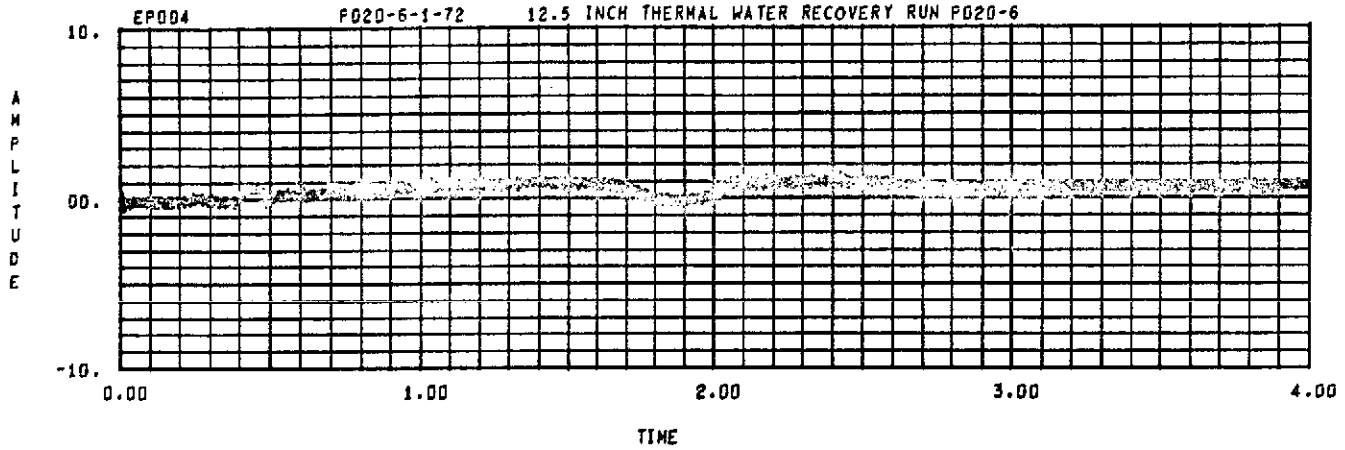


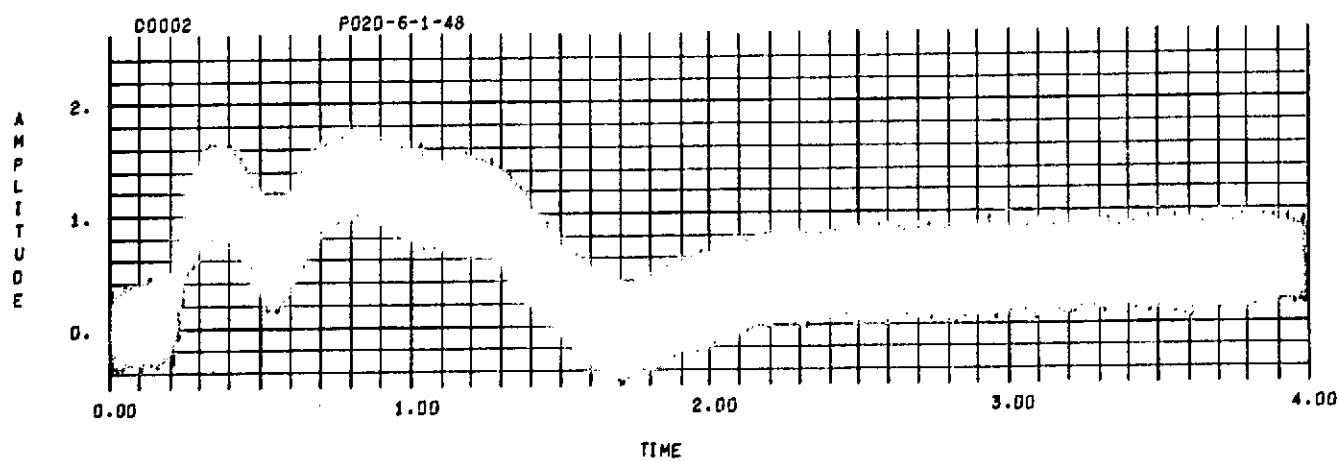
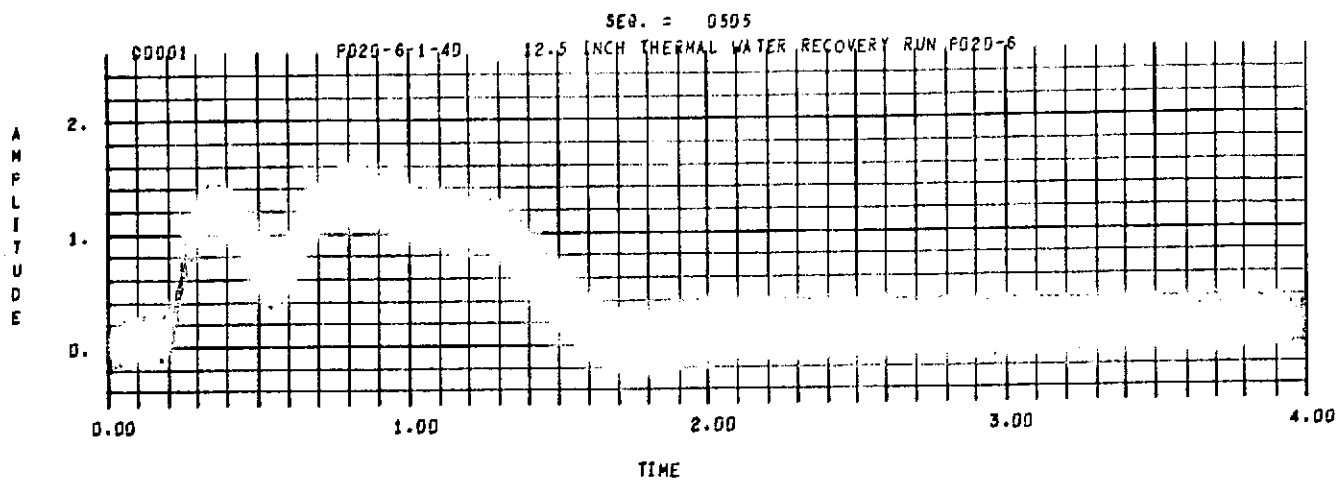


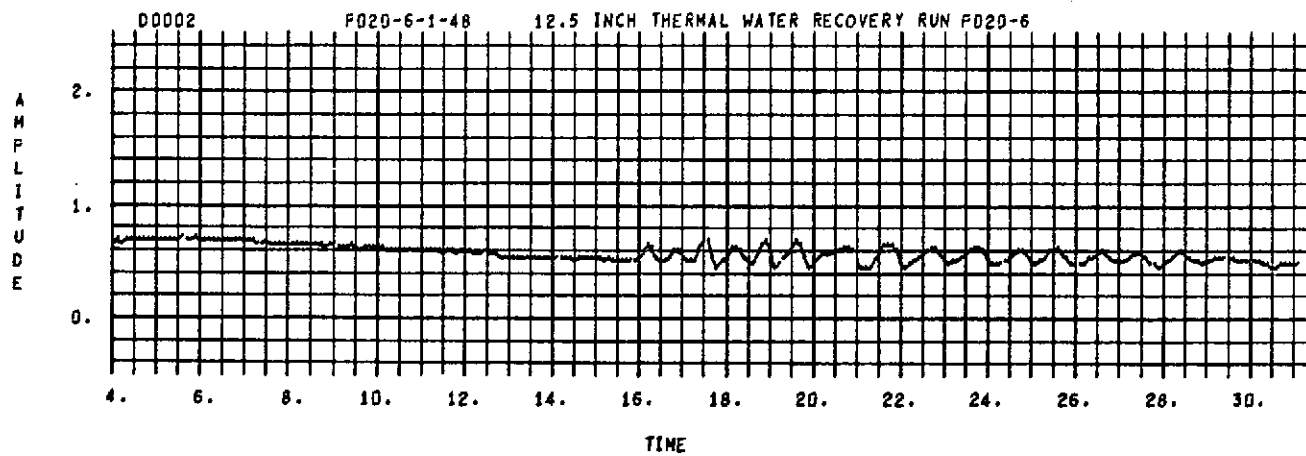
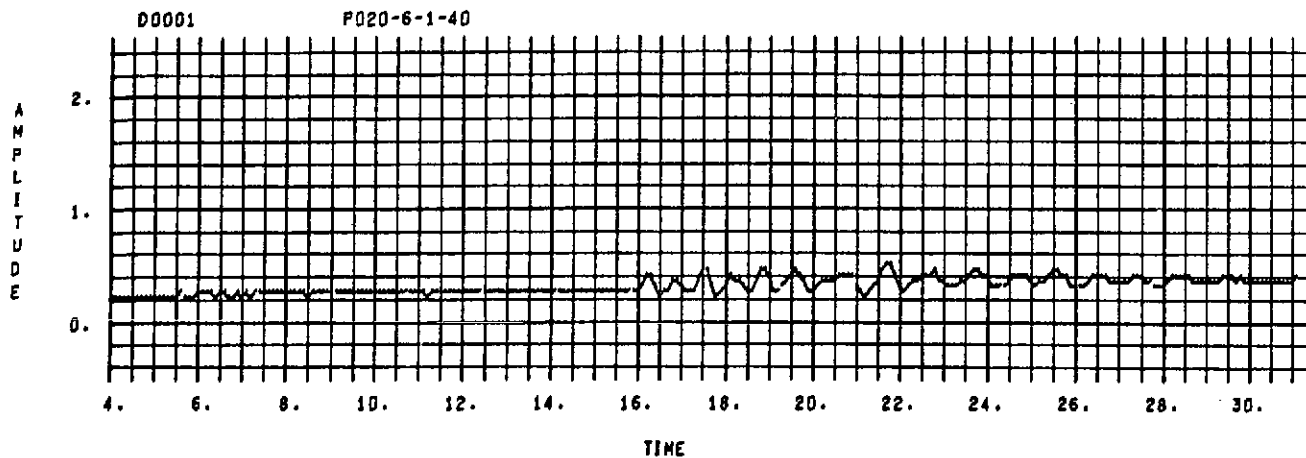


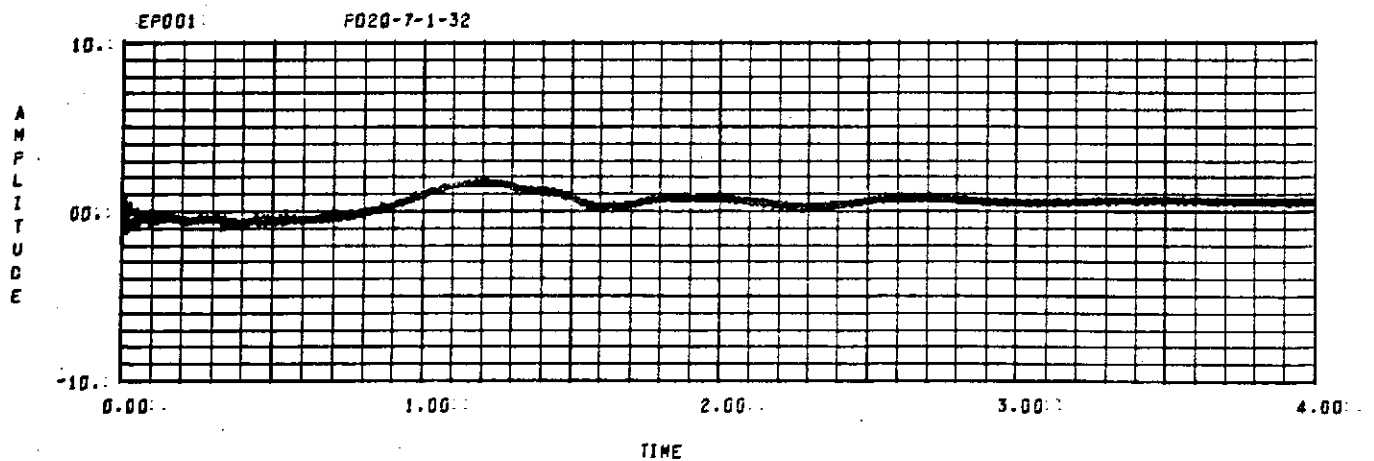
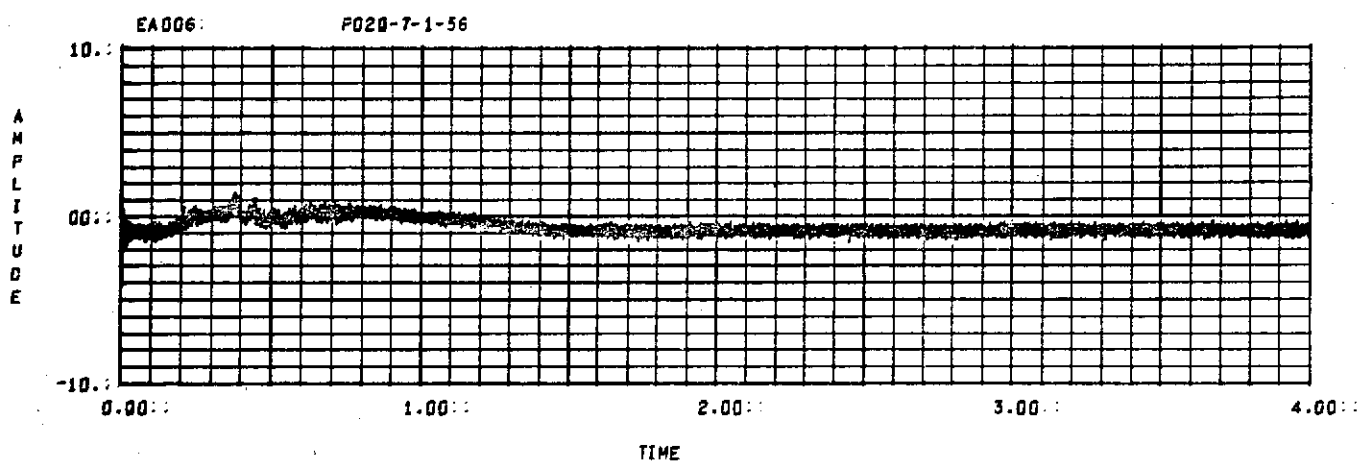
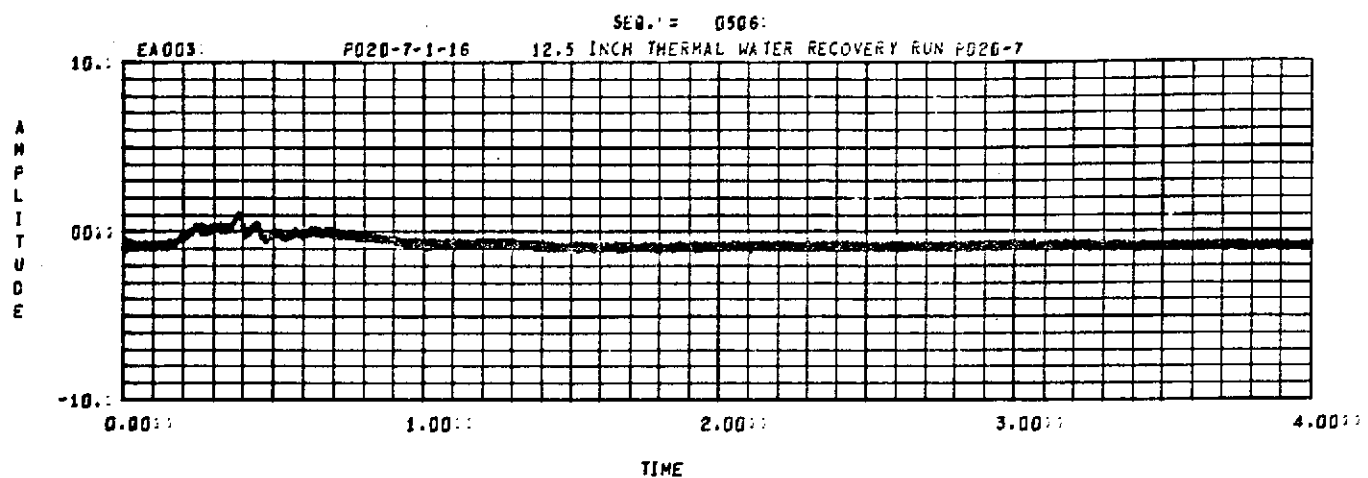
SEQ. = 0505

2



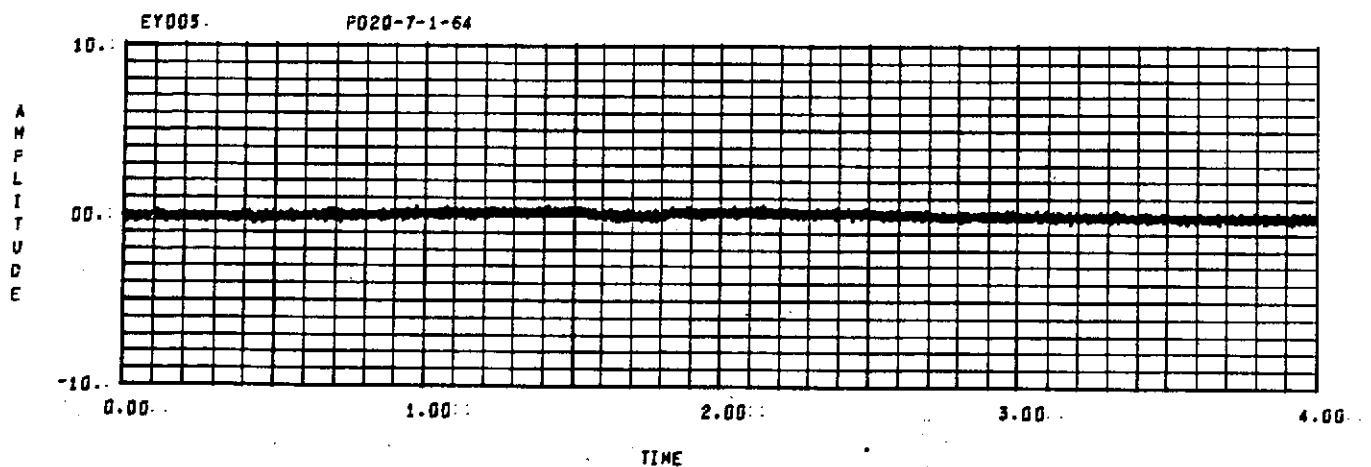
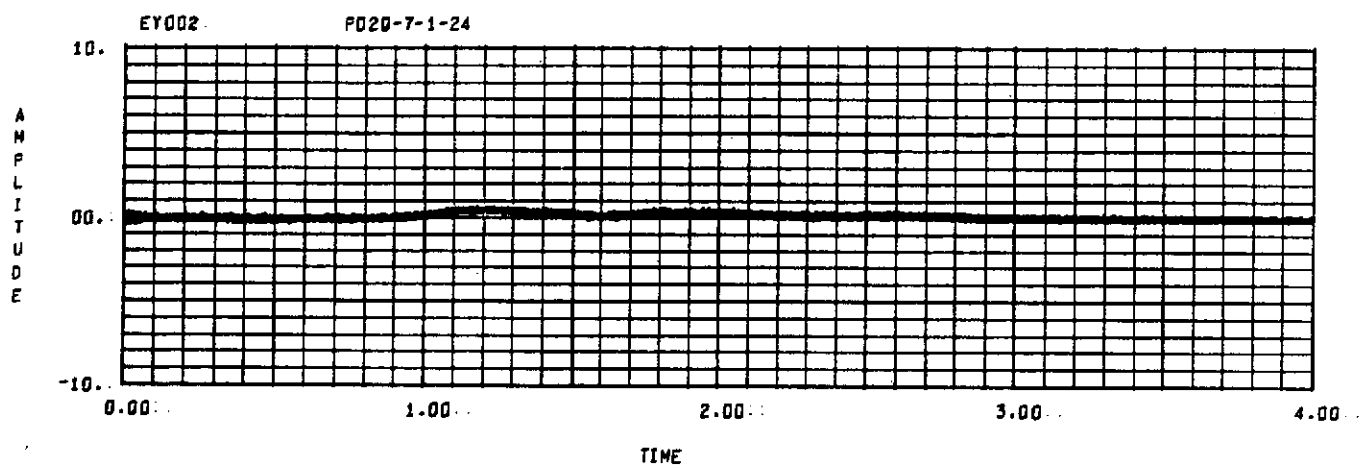
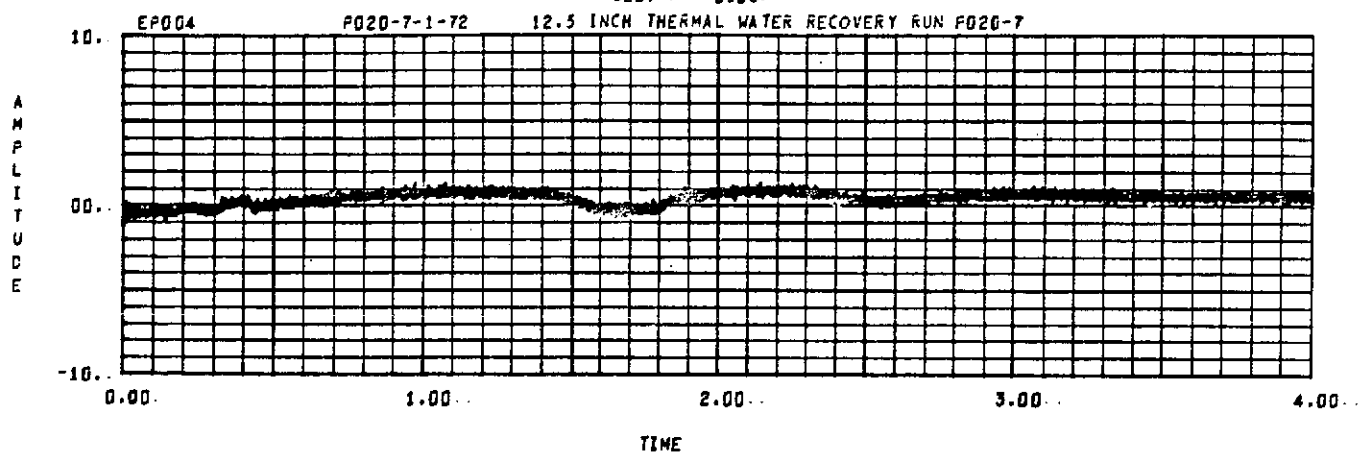


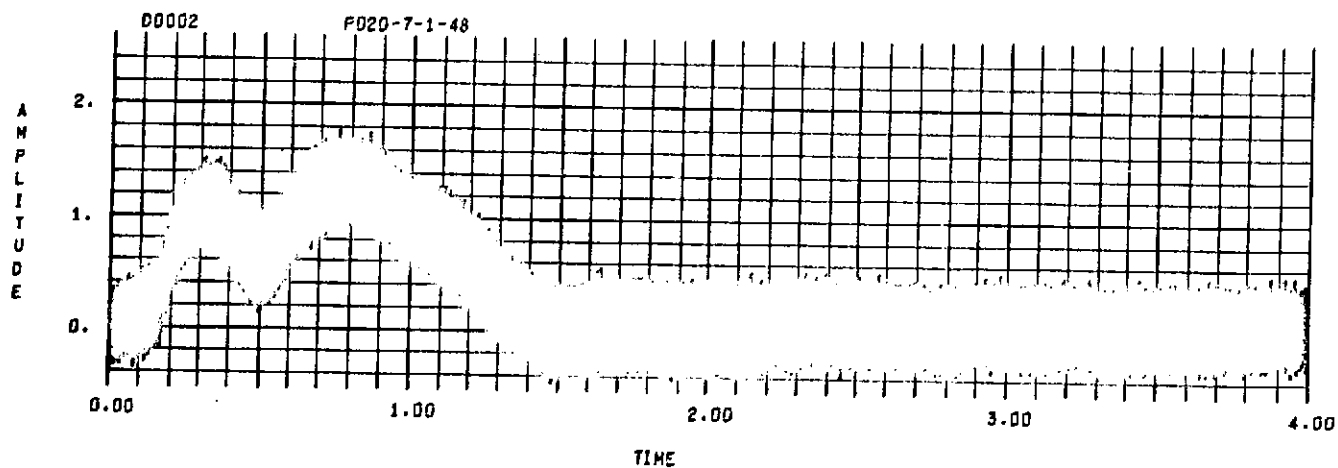
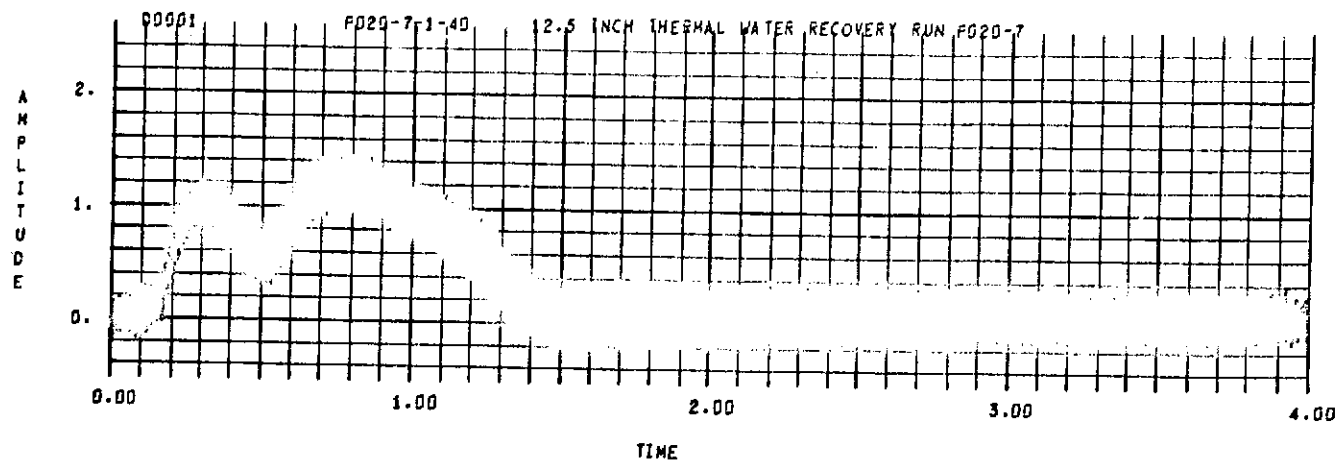


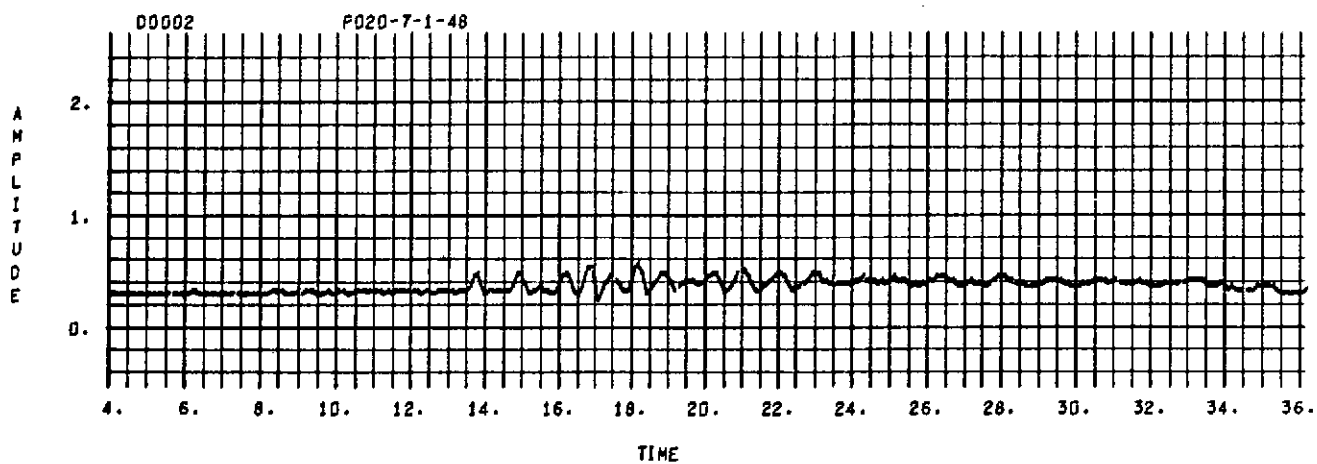
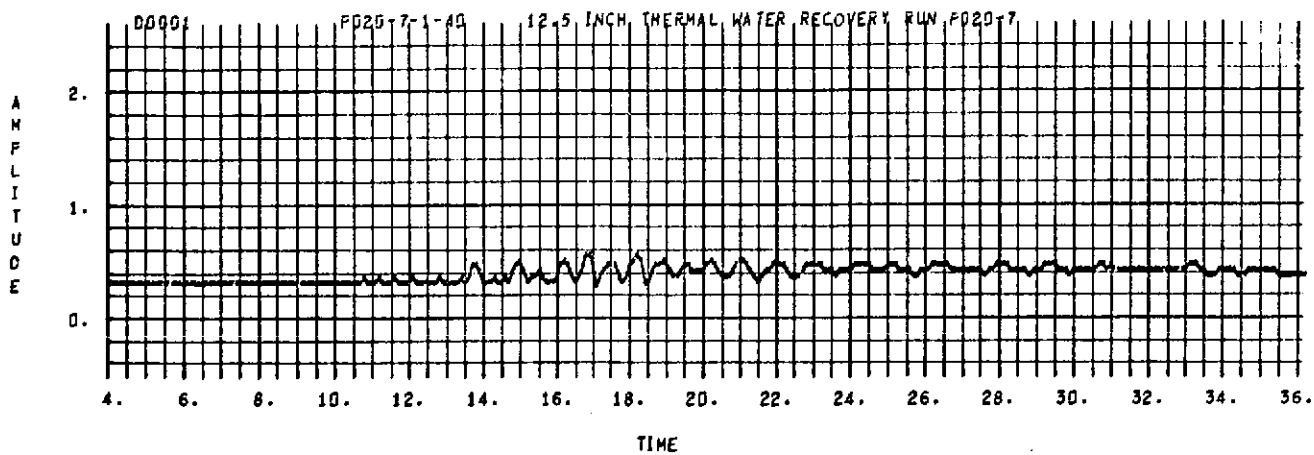


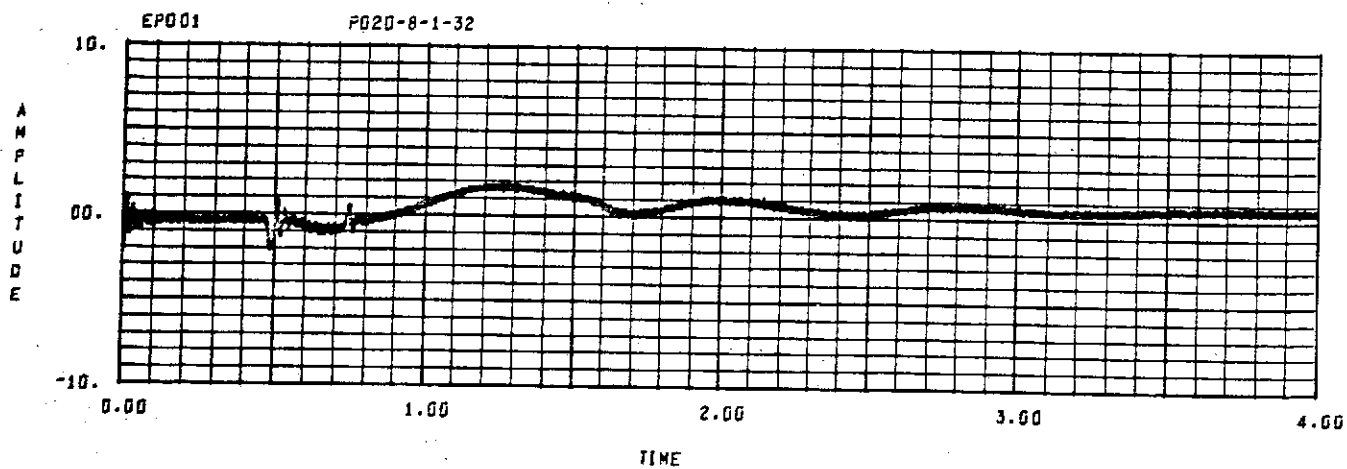
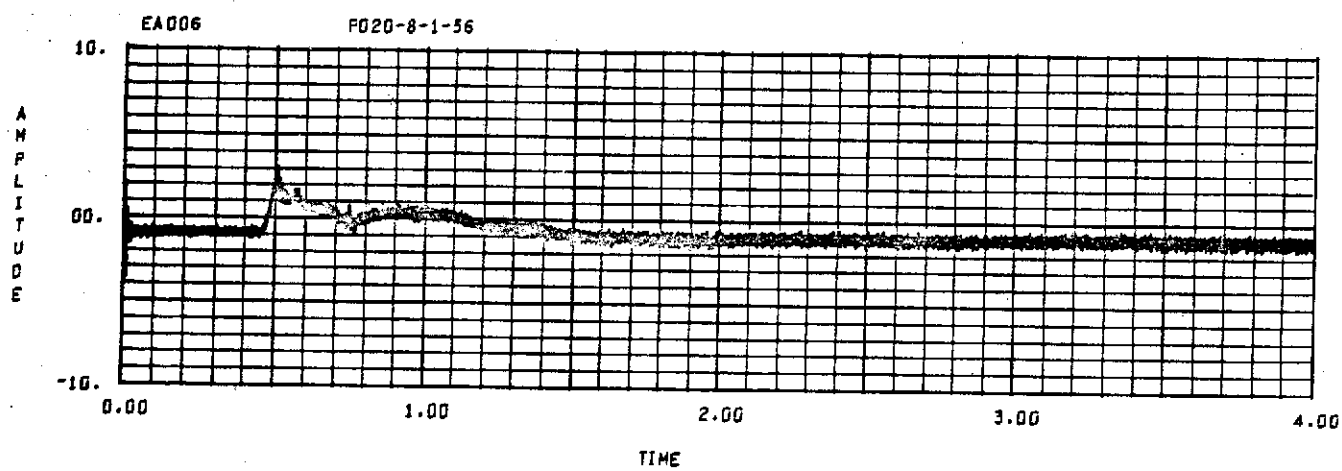
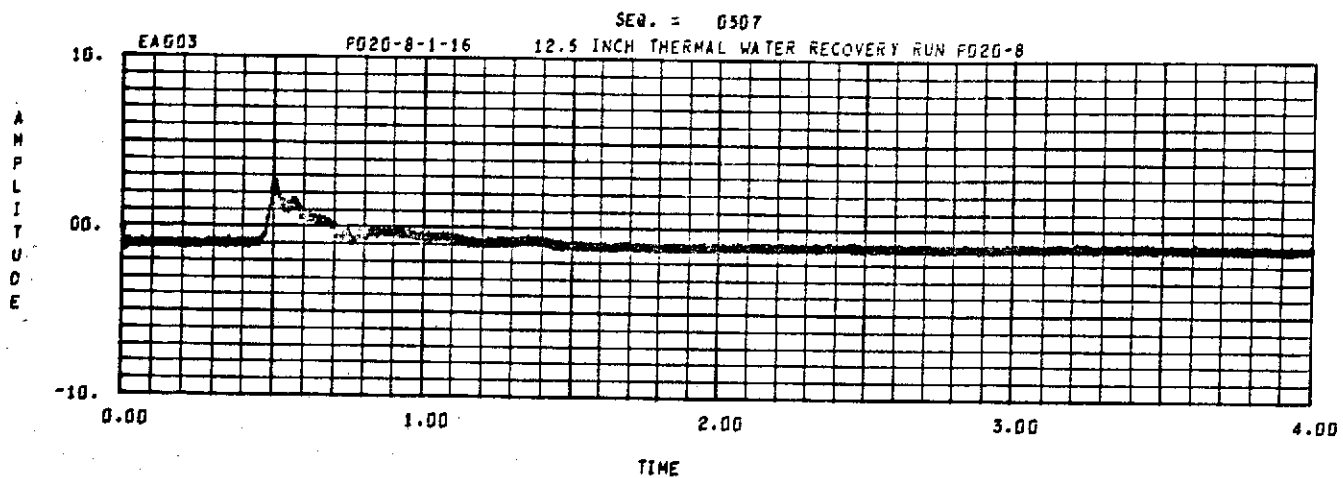
Seq. = 0506.

2



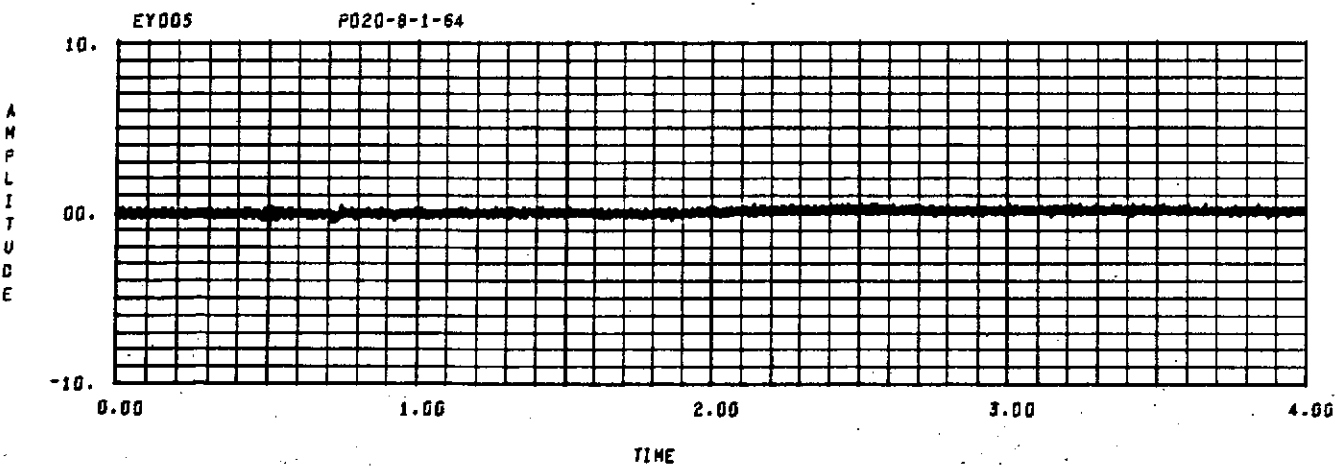
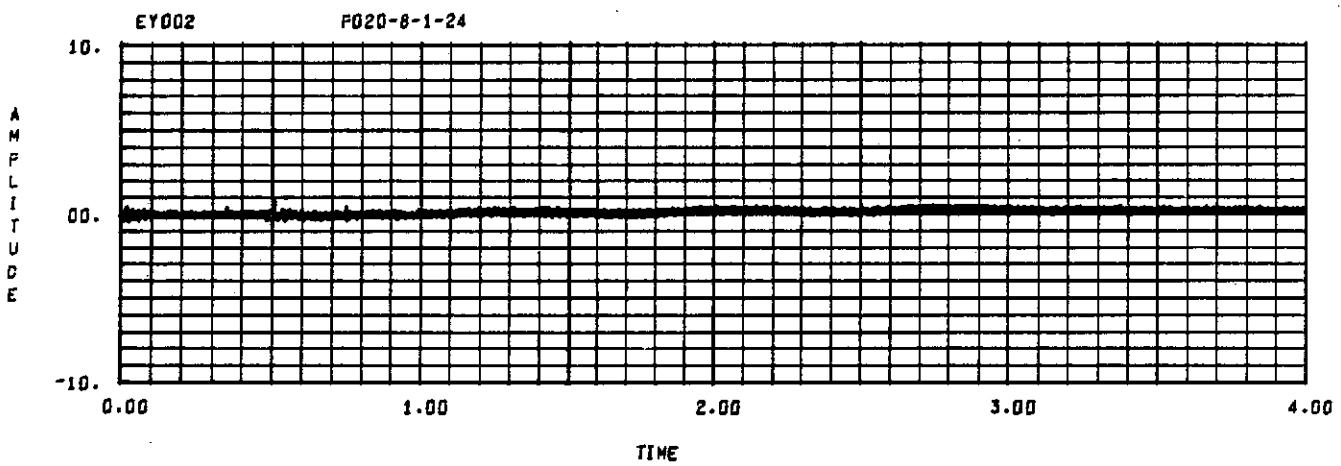
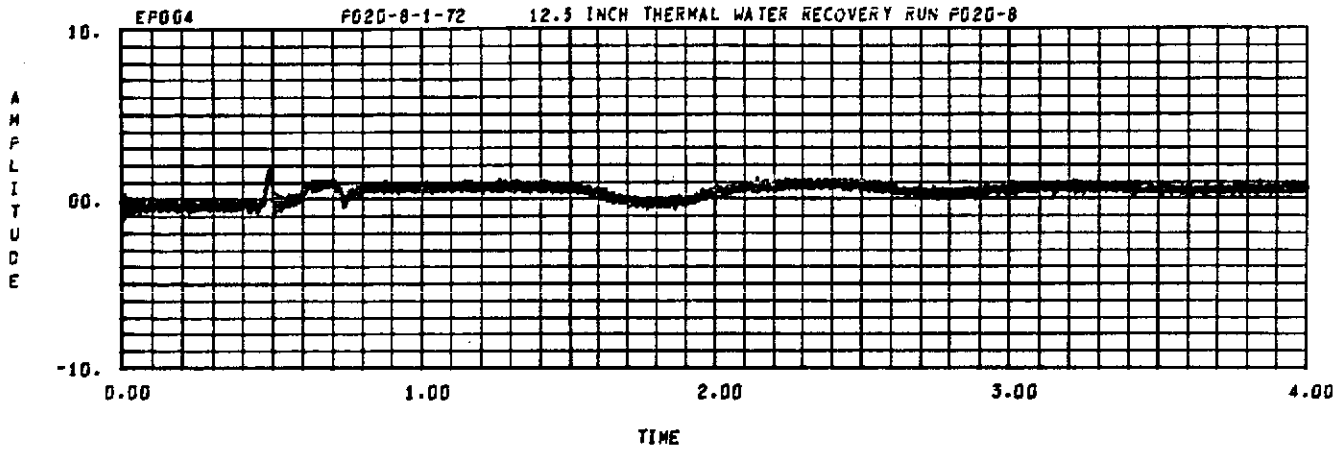


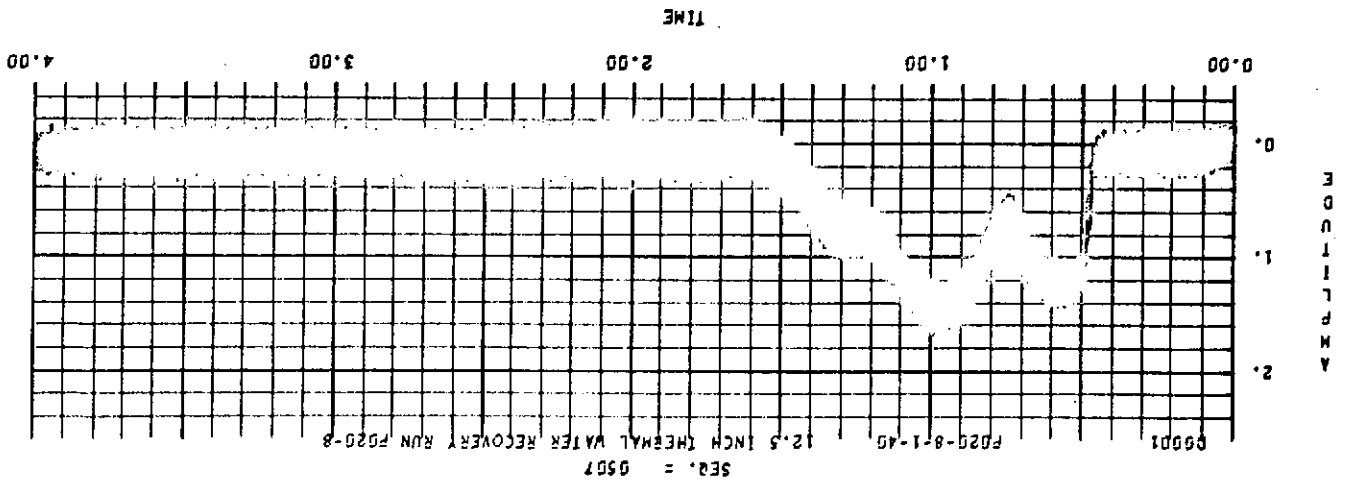
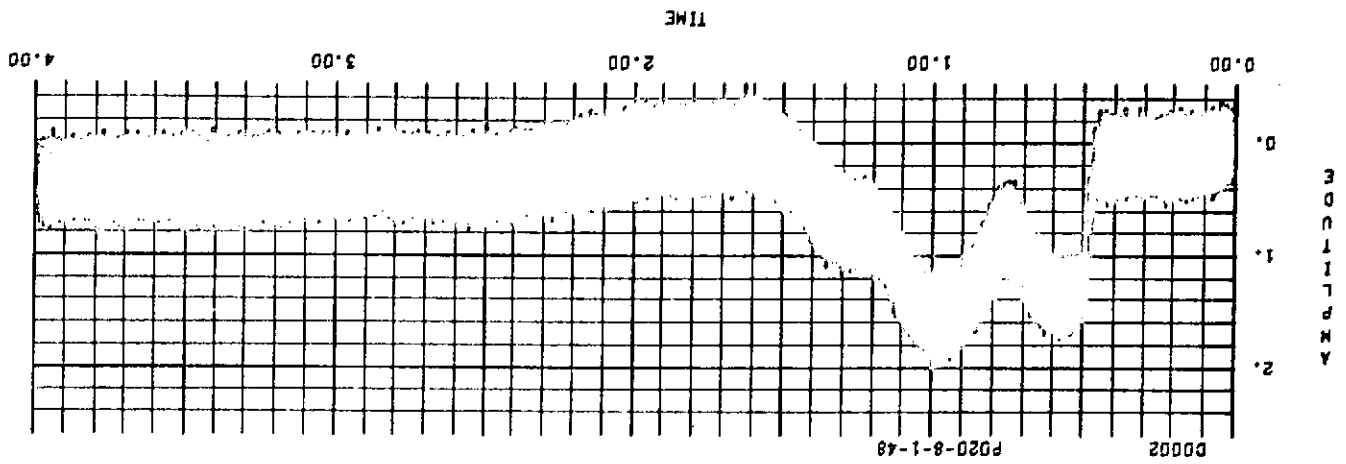


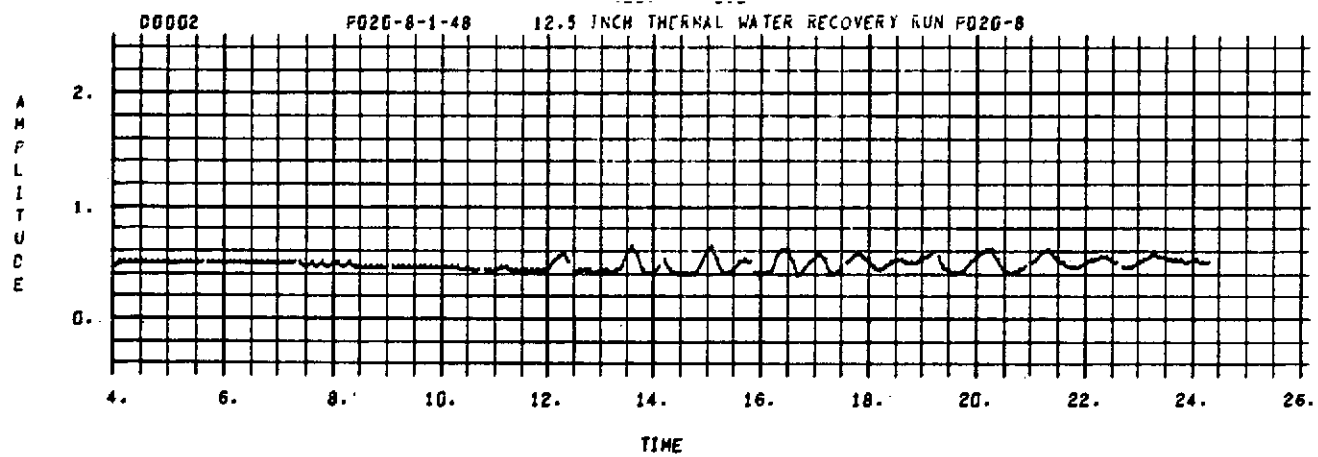
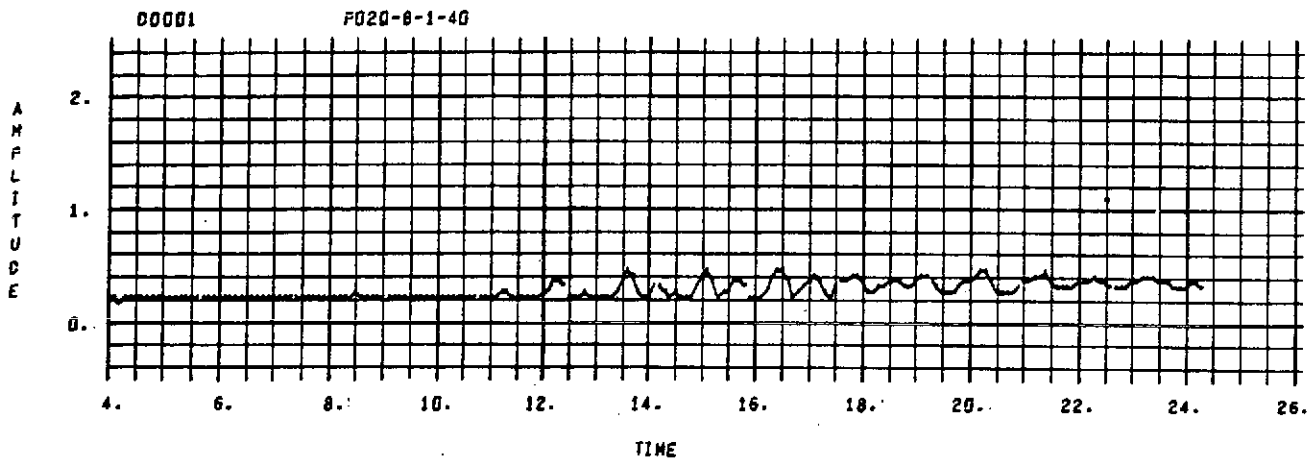


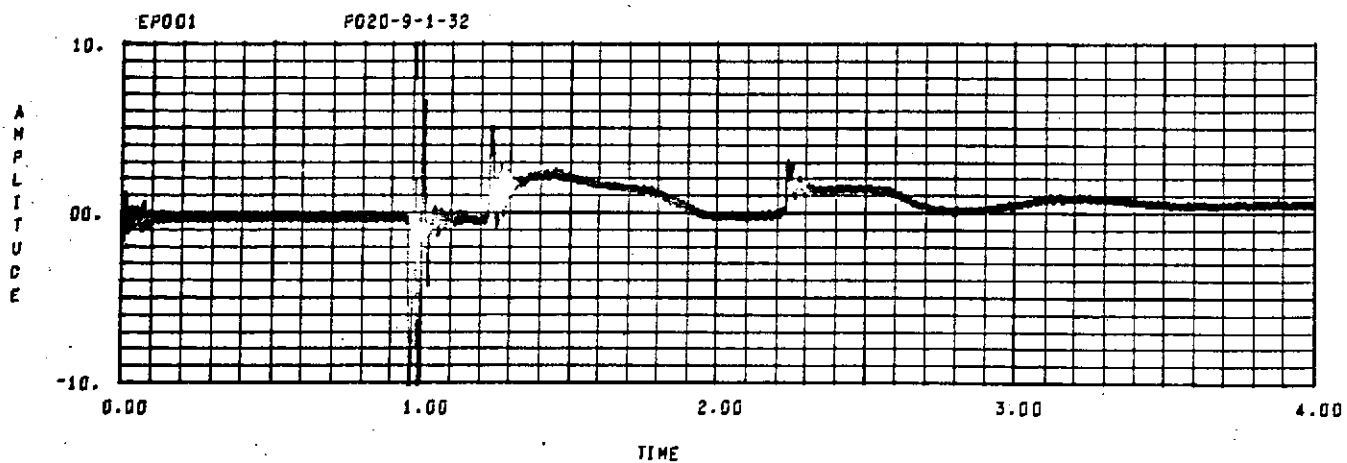
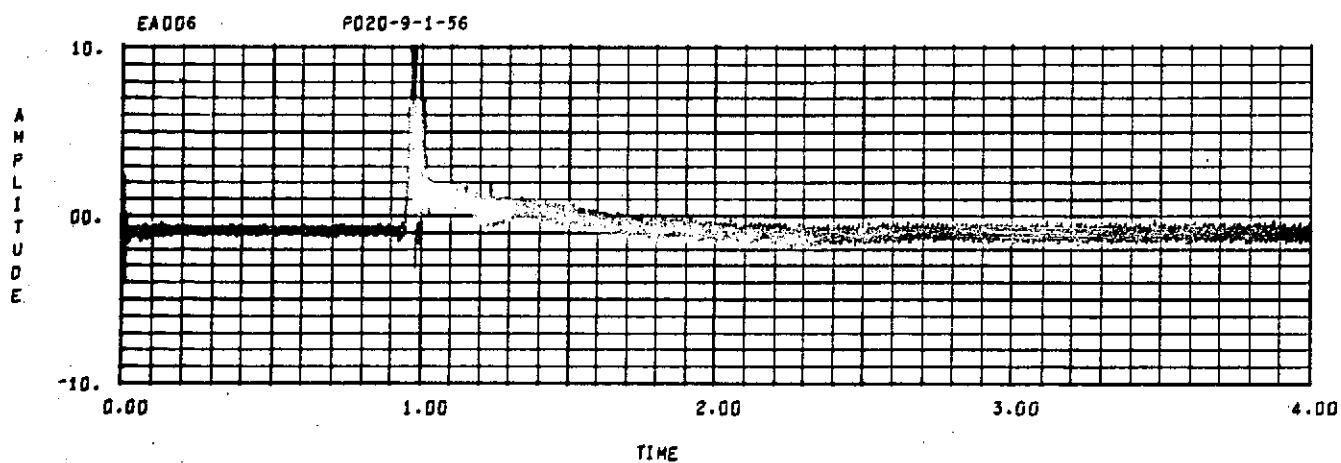
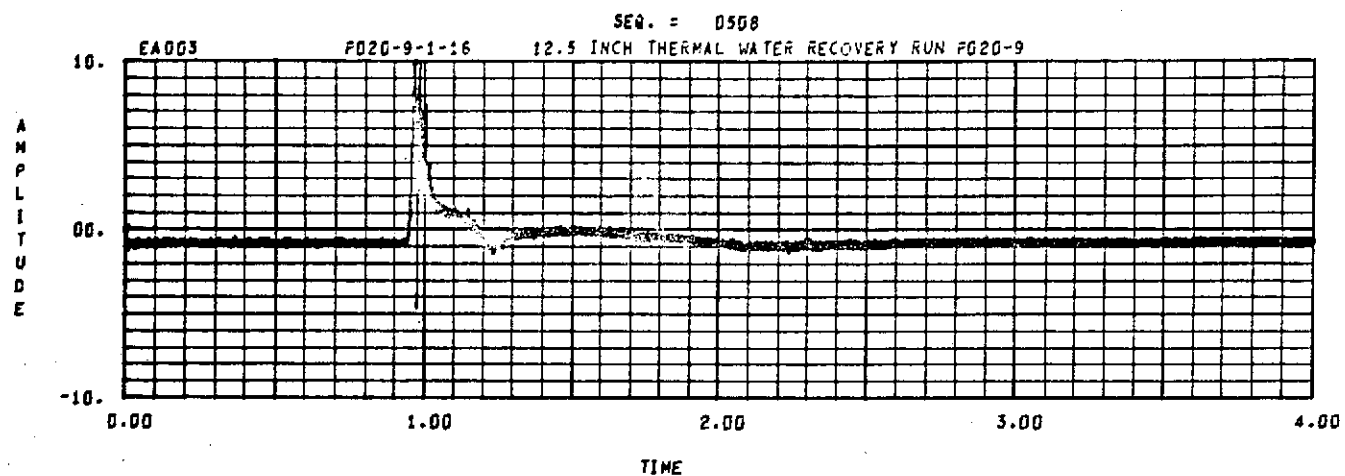
SEQ. = 0907

2

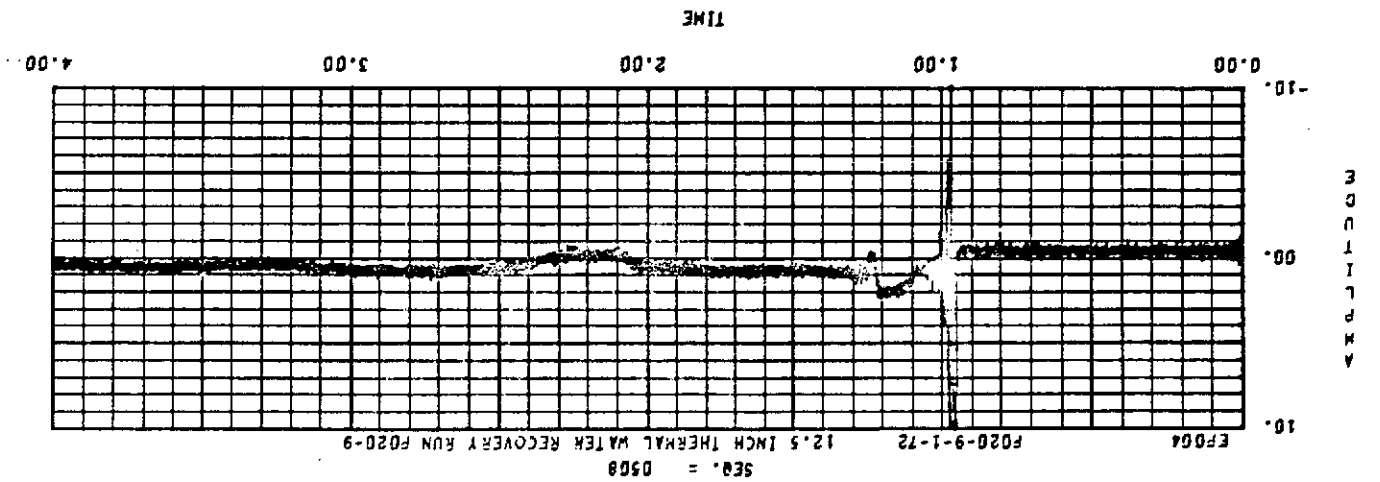
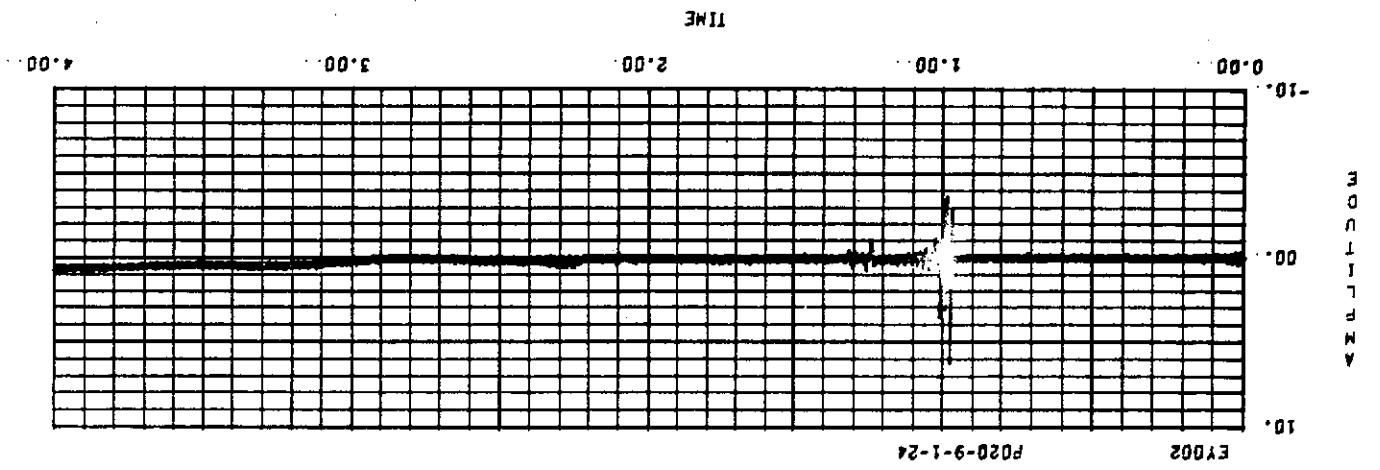
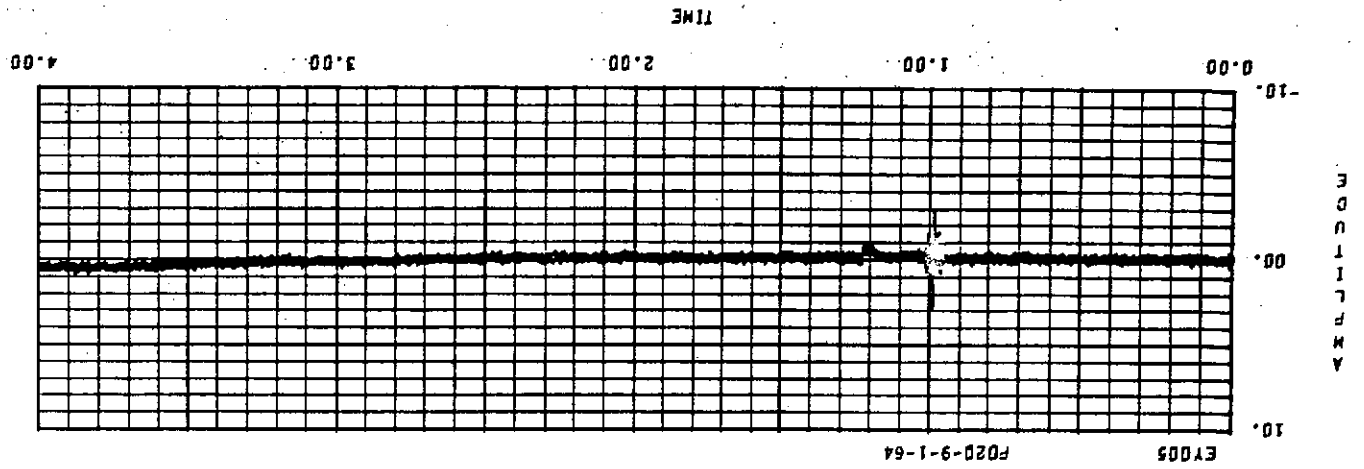


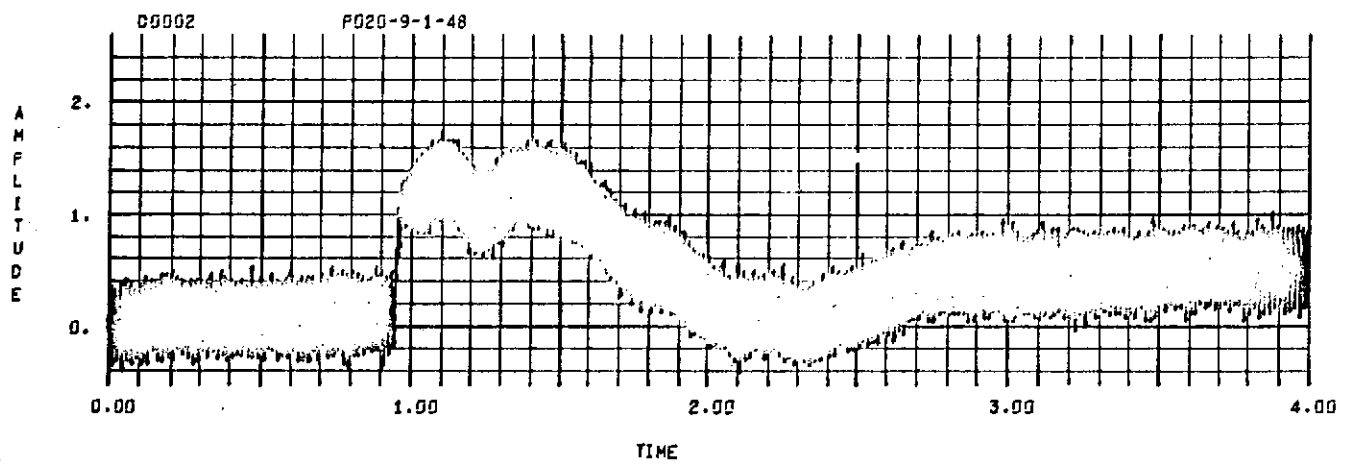
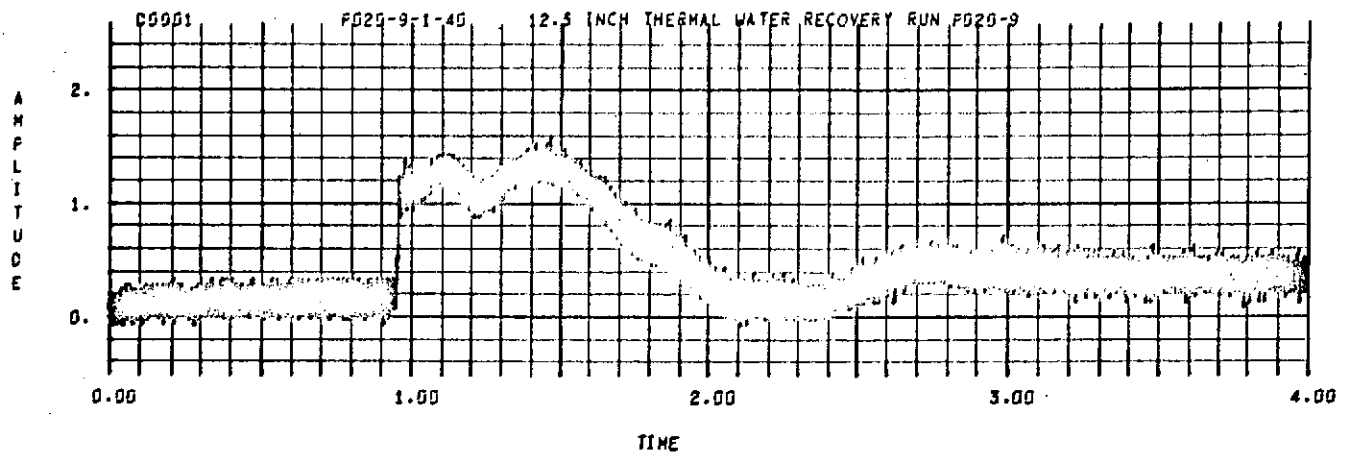


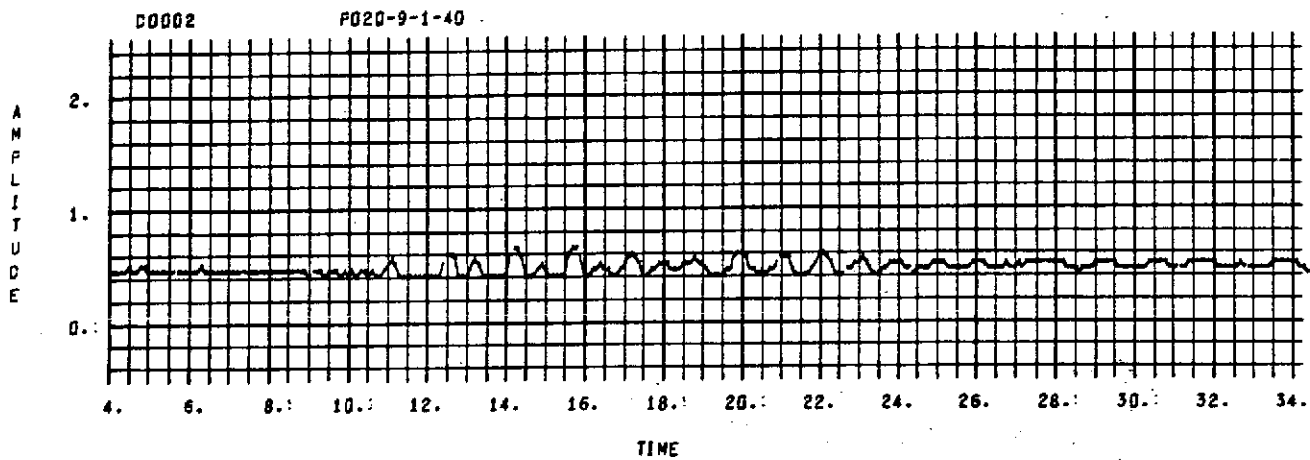


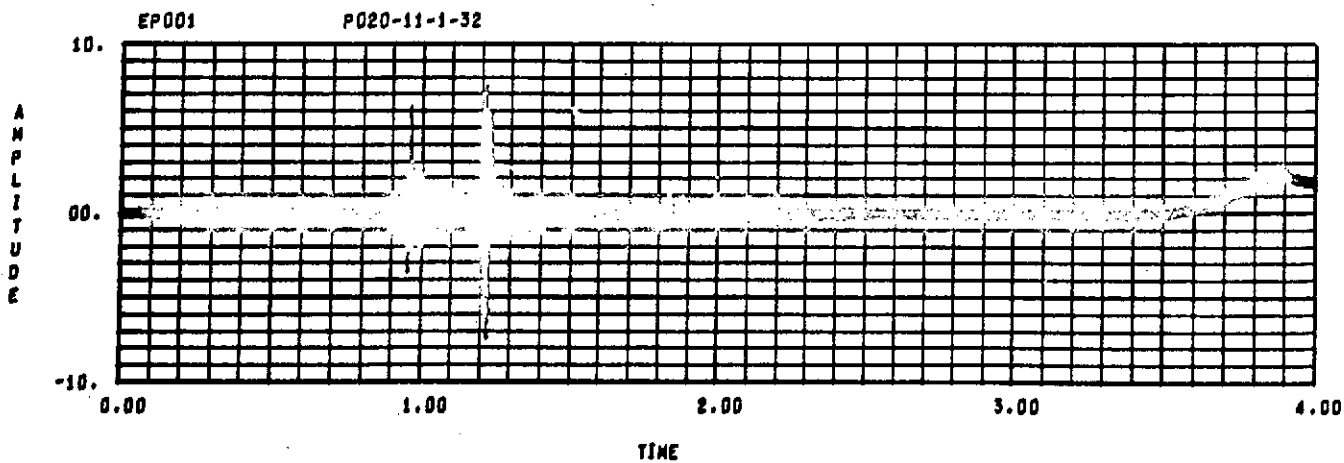
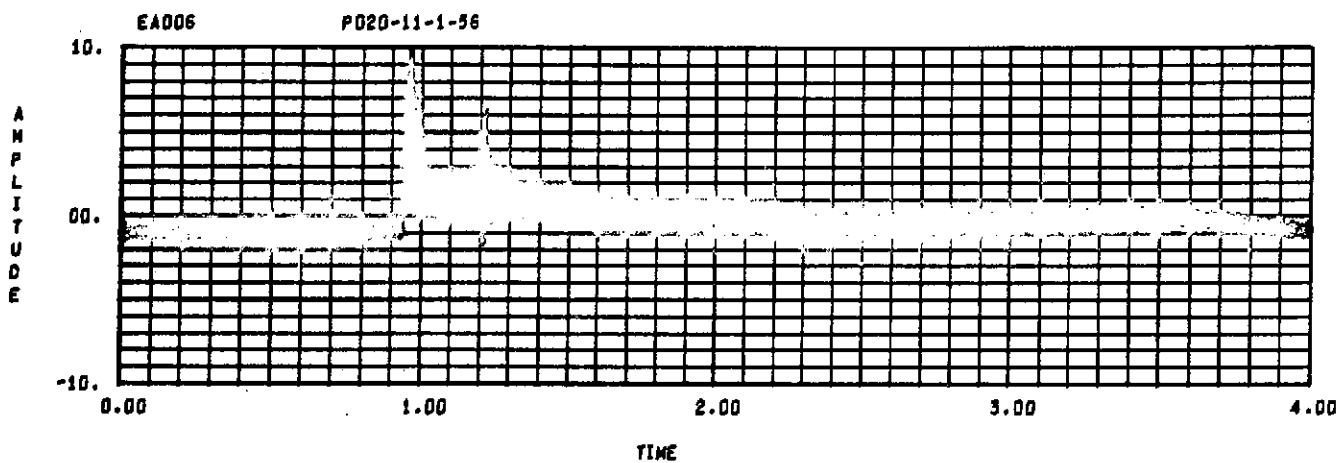
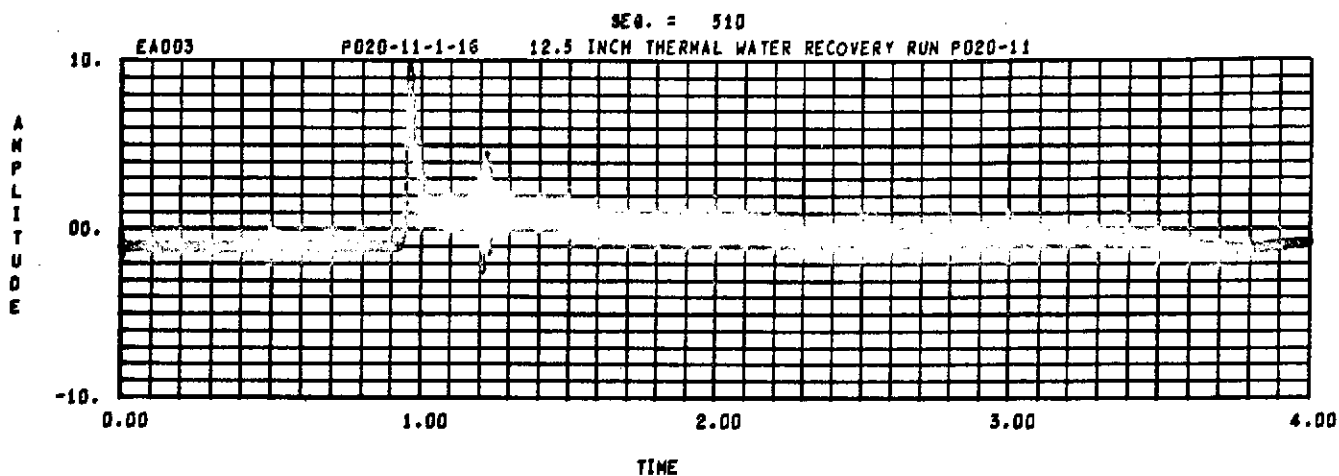


B-34



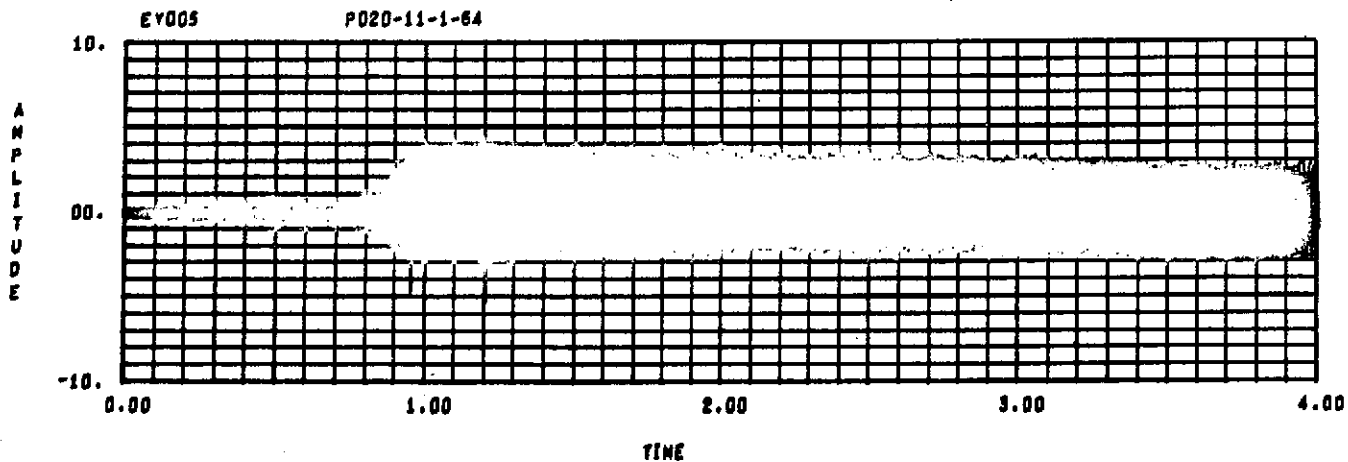
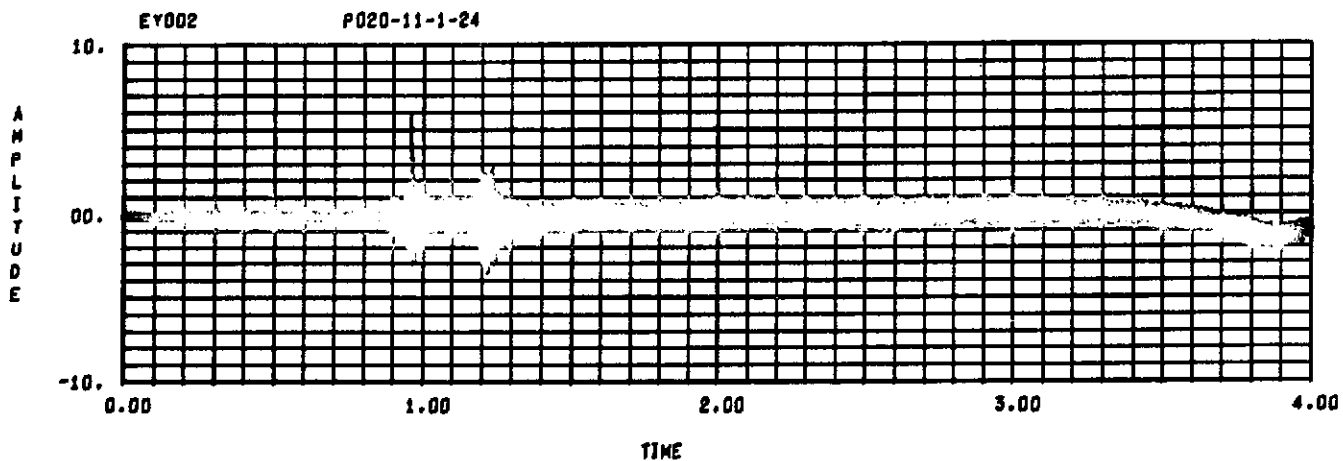
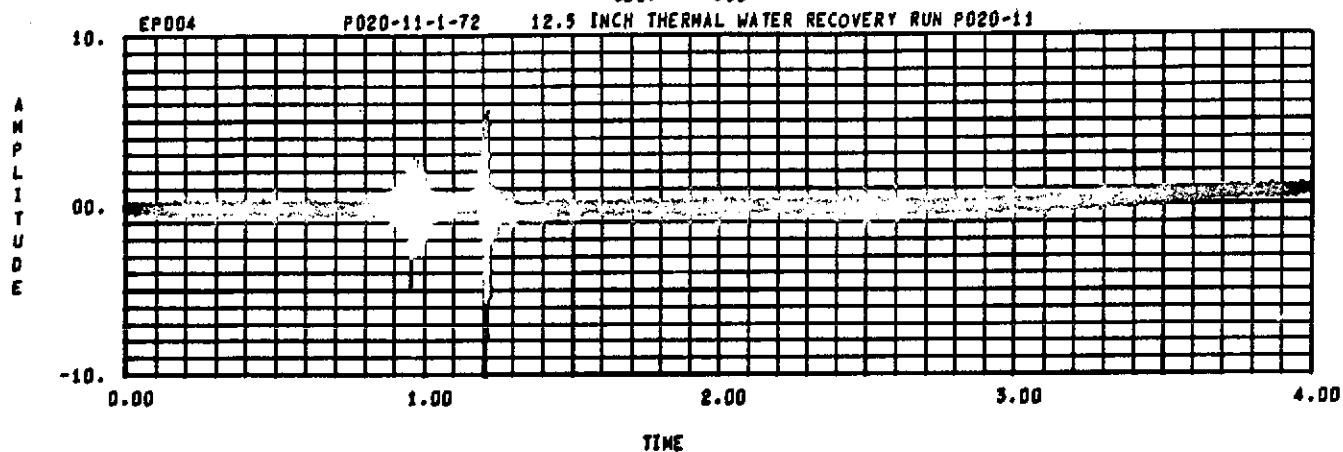


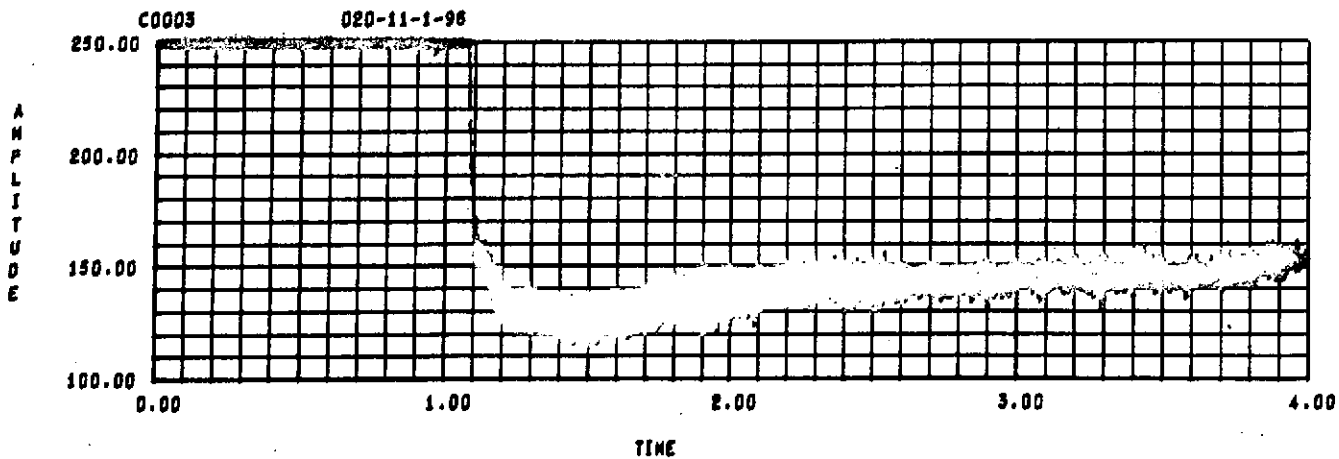
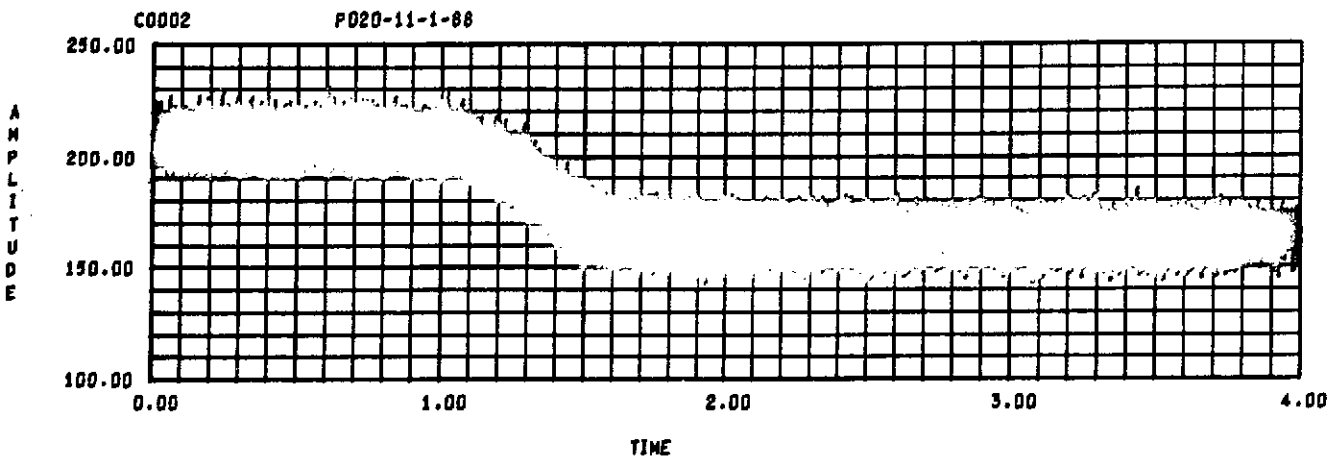
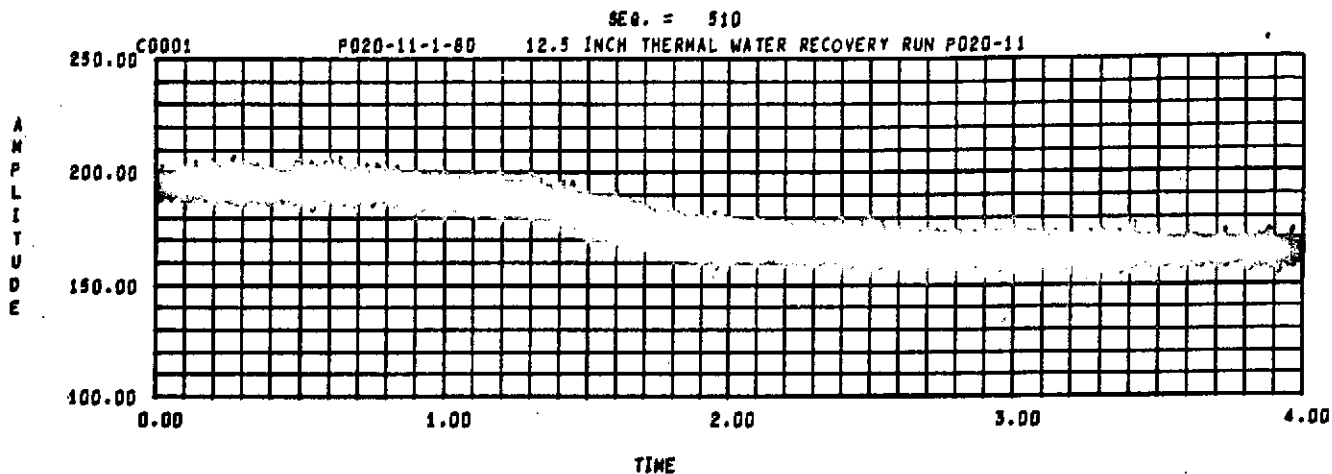


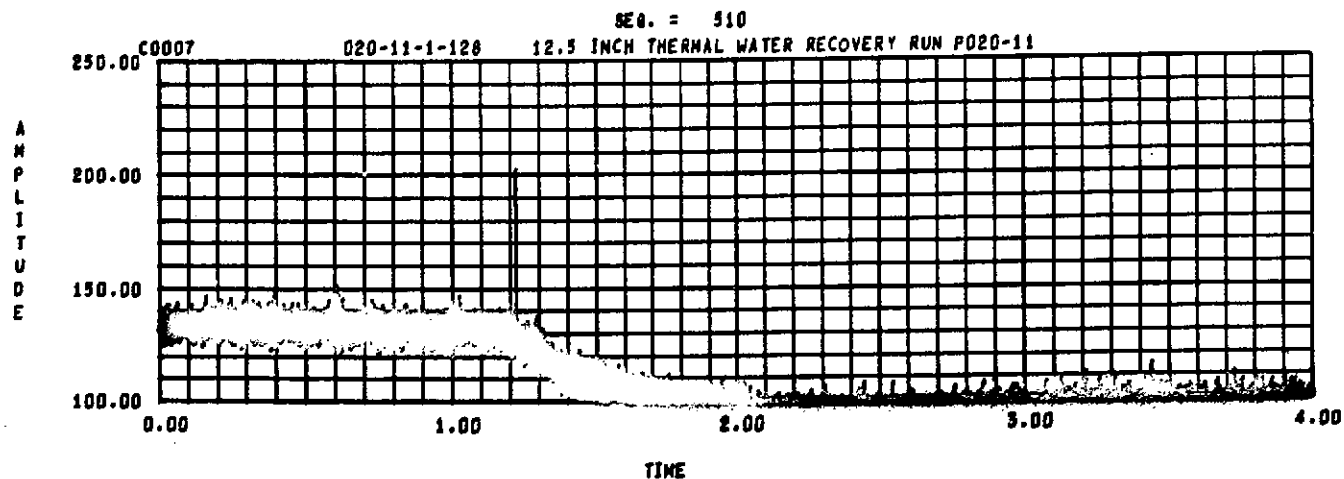
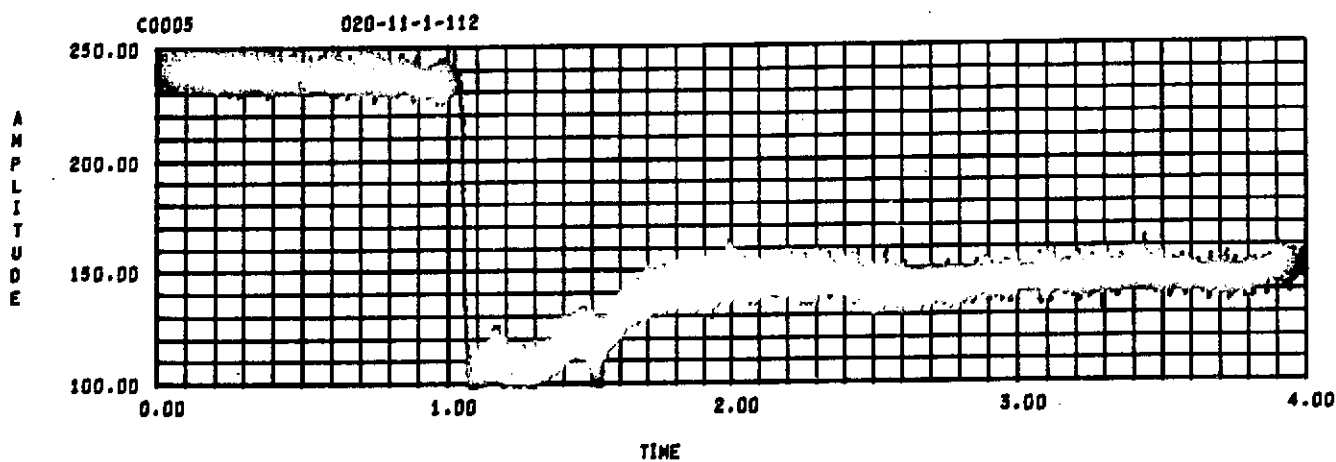
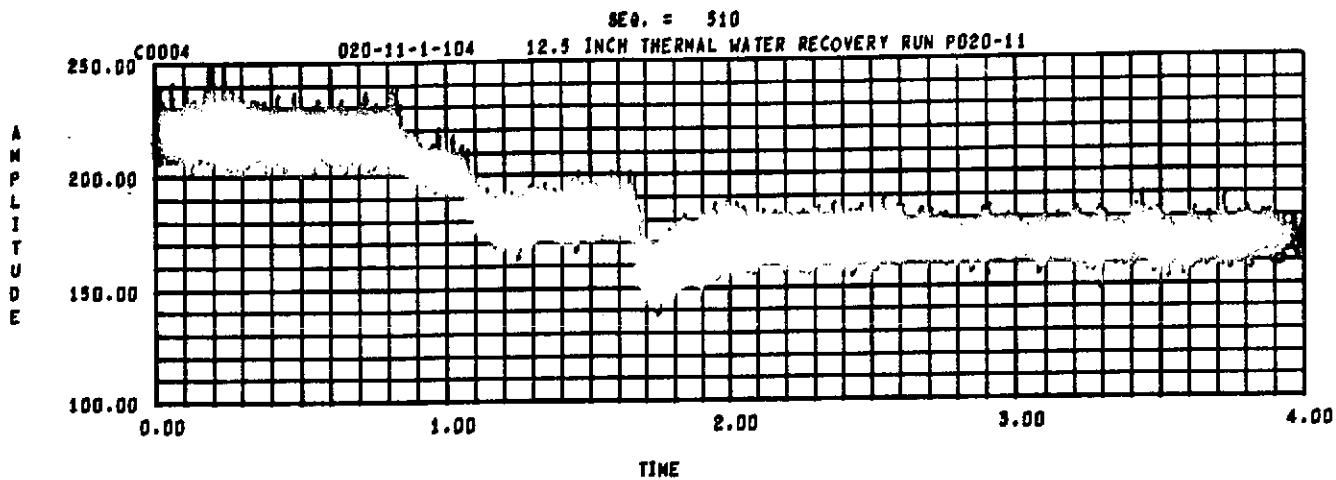


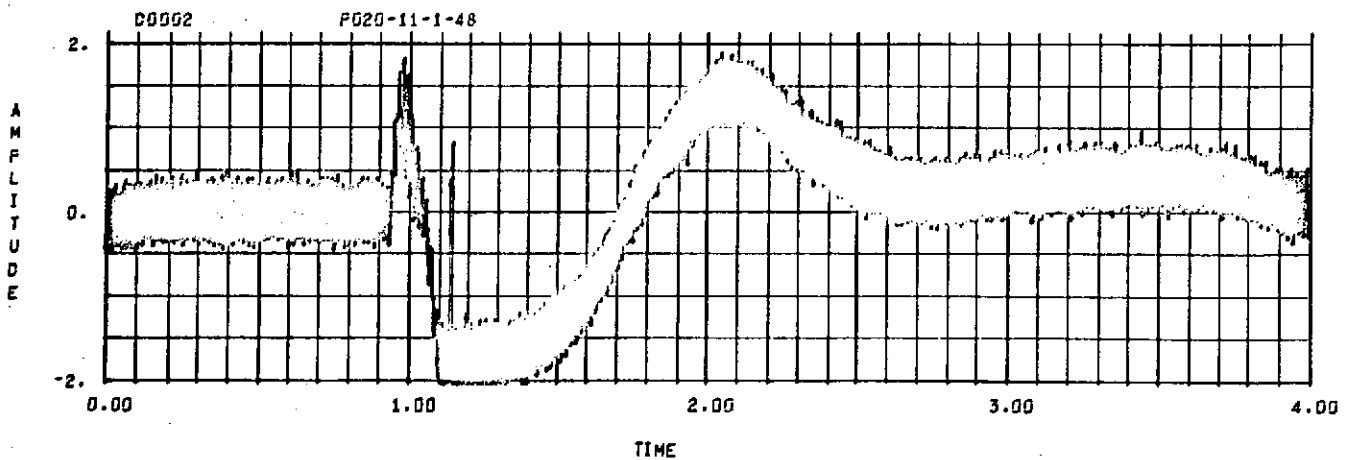
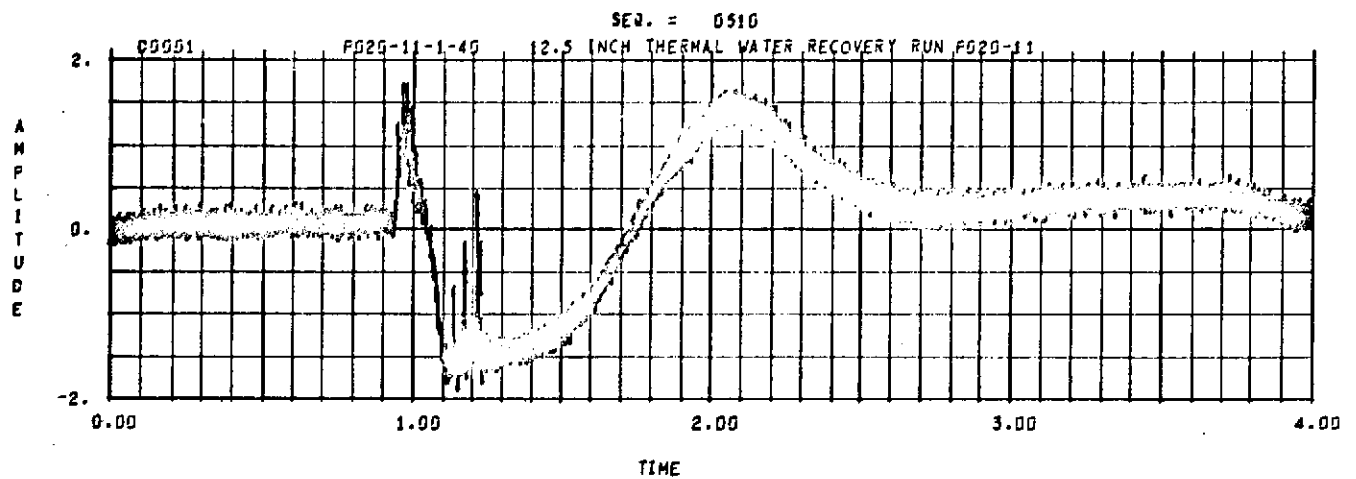
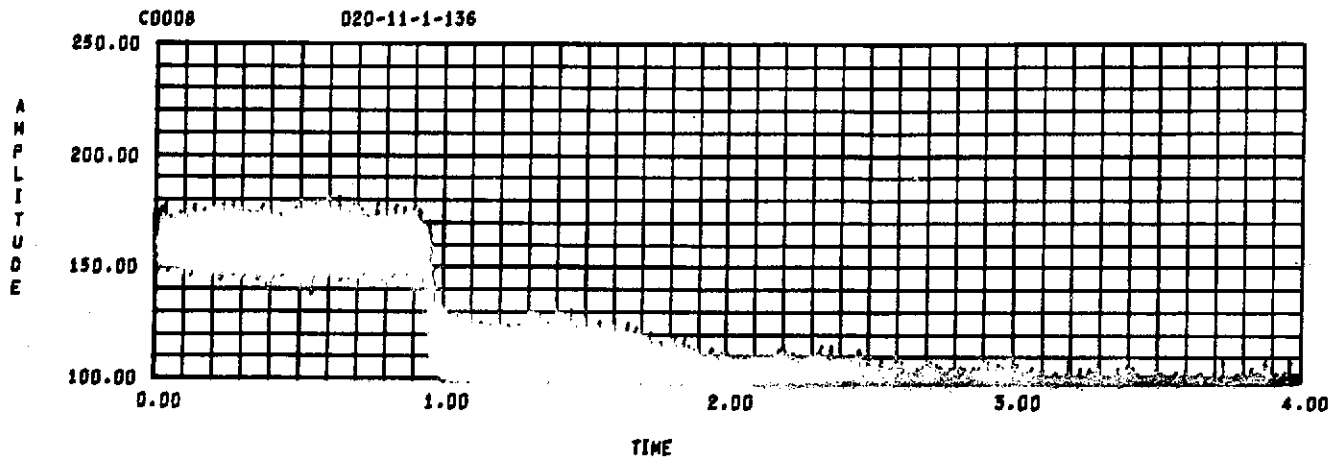
SEQ. = 510

2



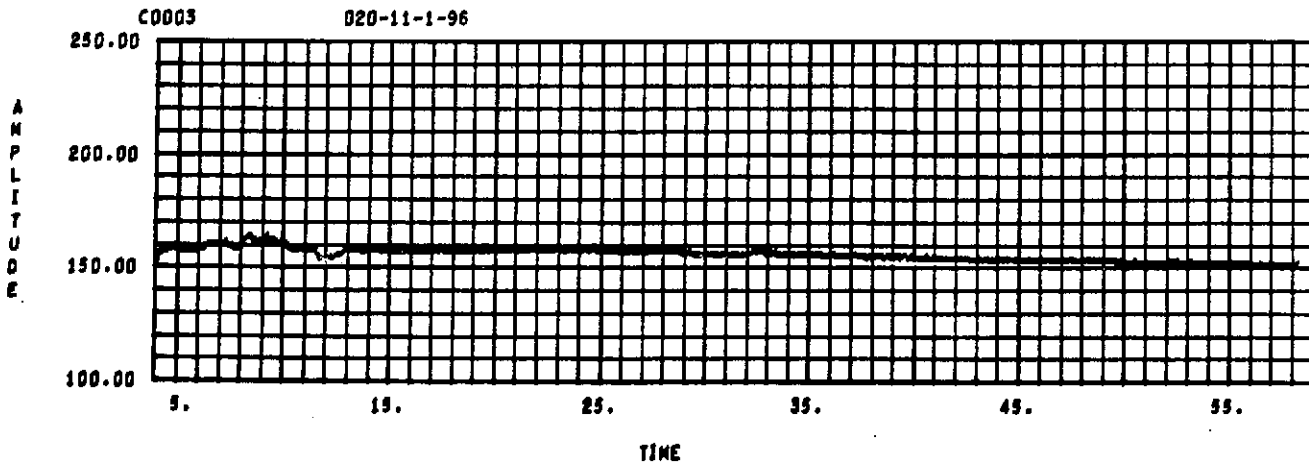
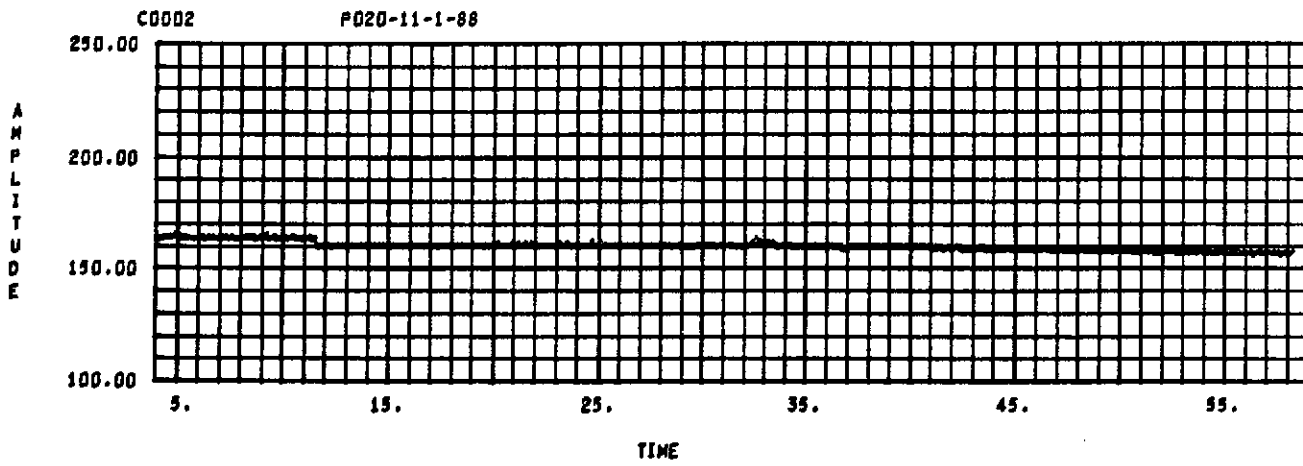
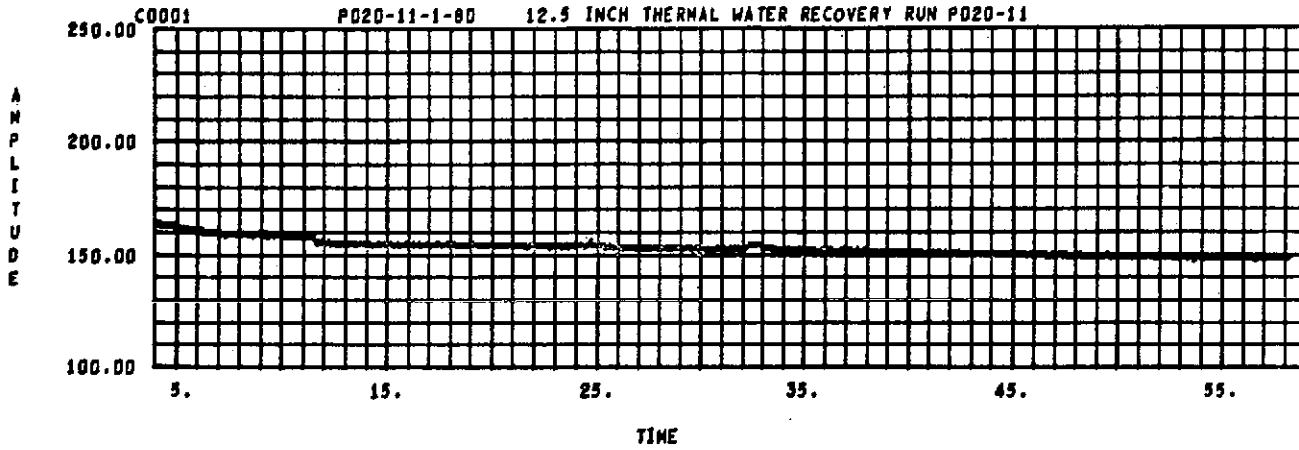


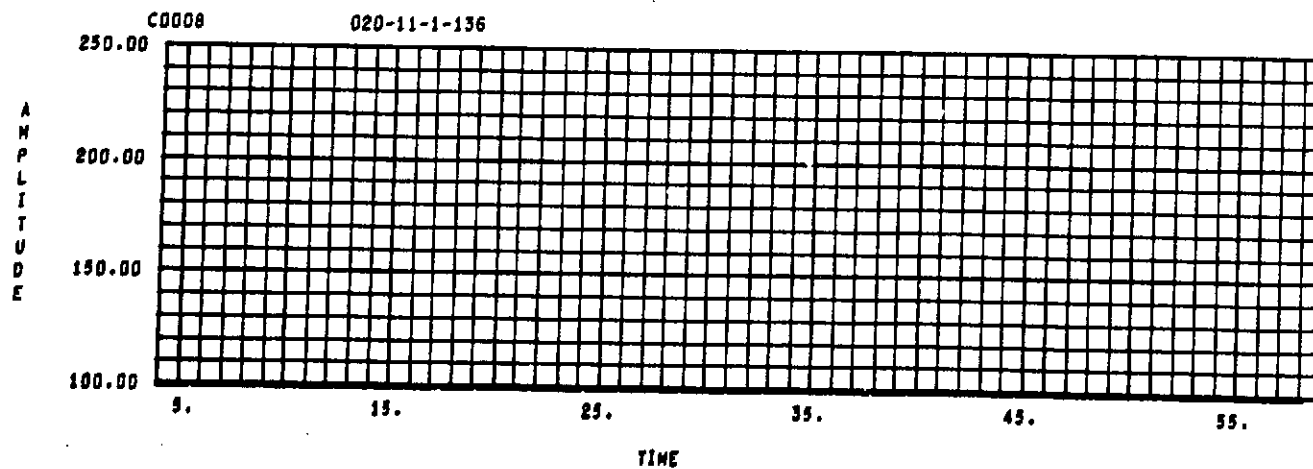
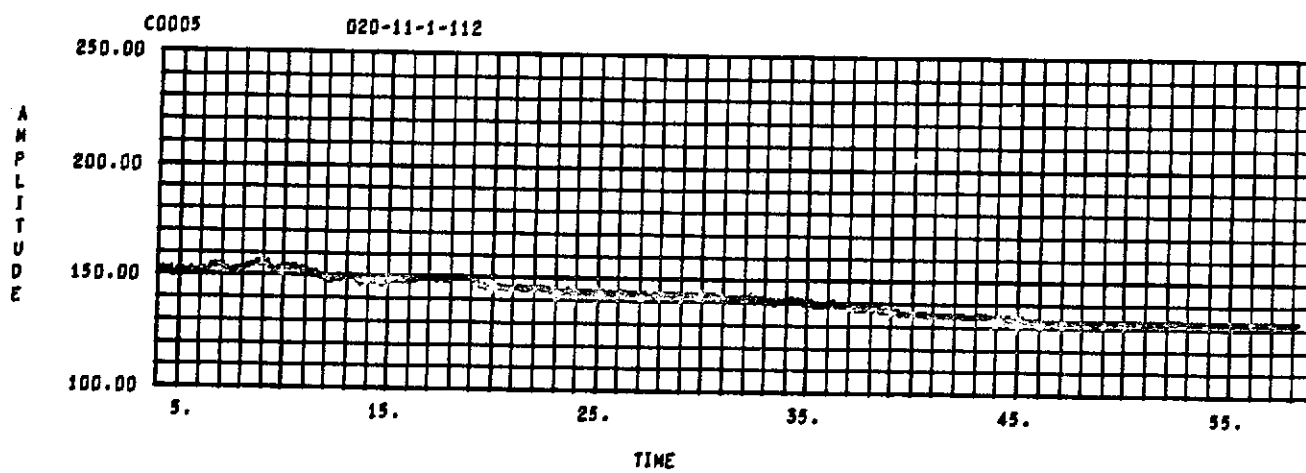
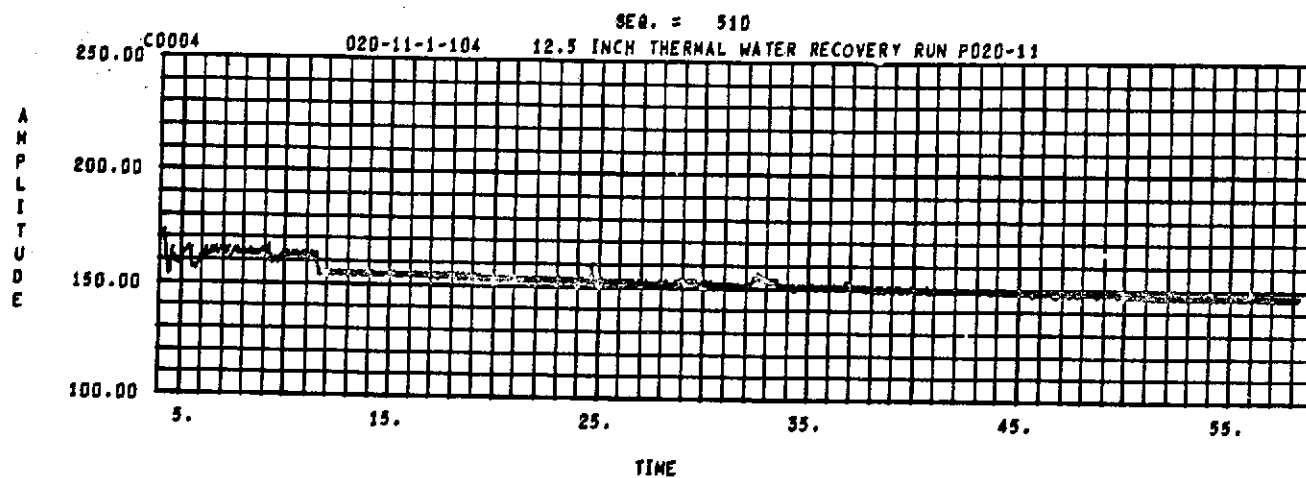




SEQ. = 510

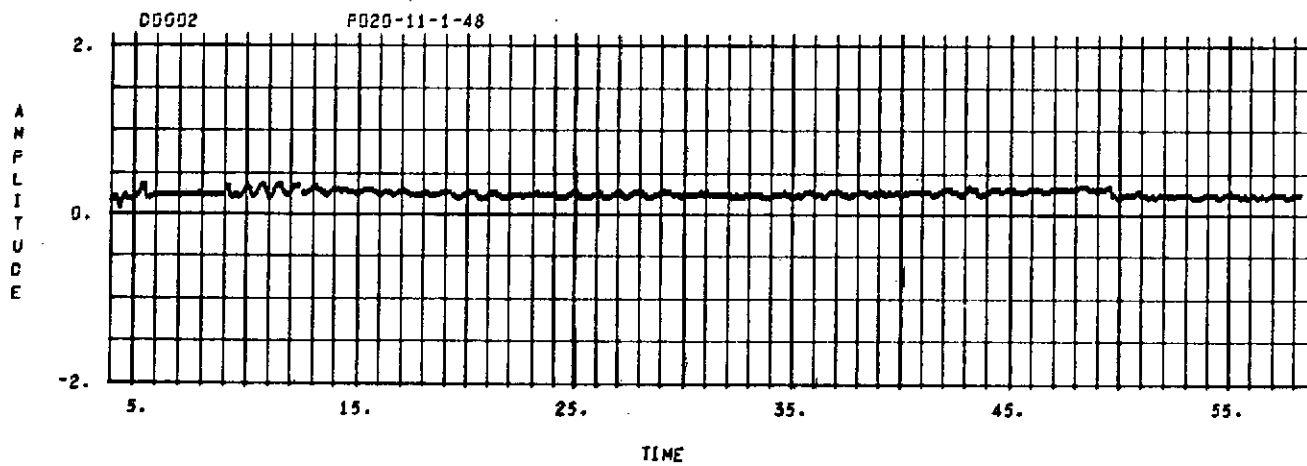
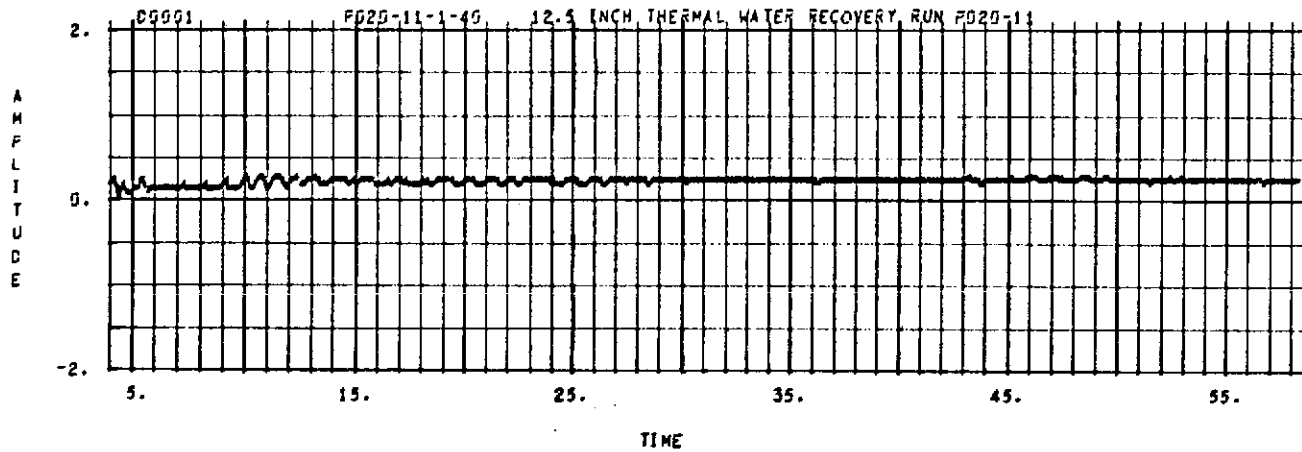
11



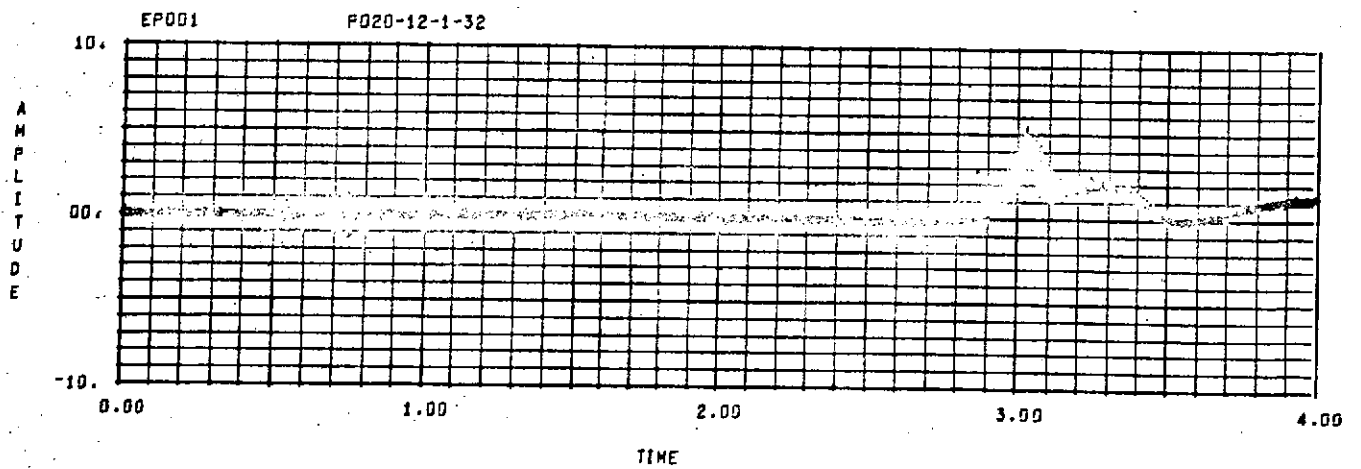
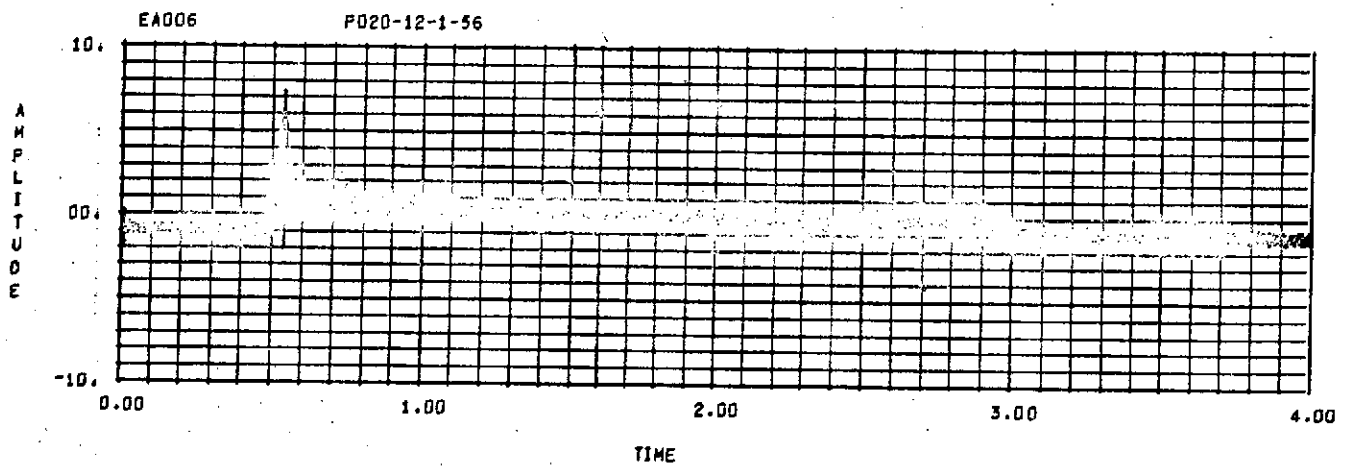
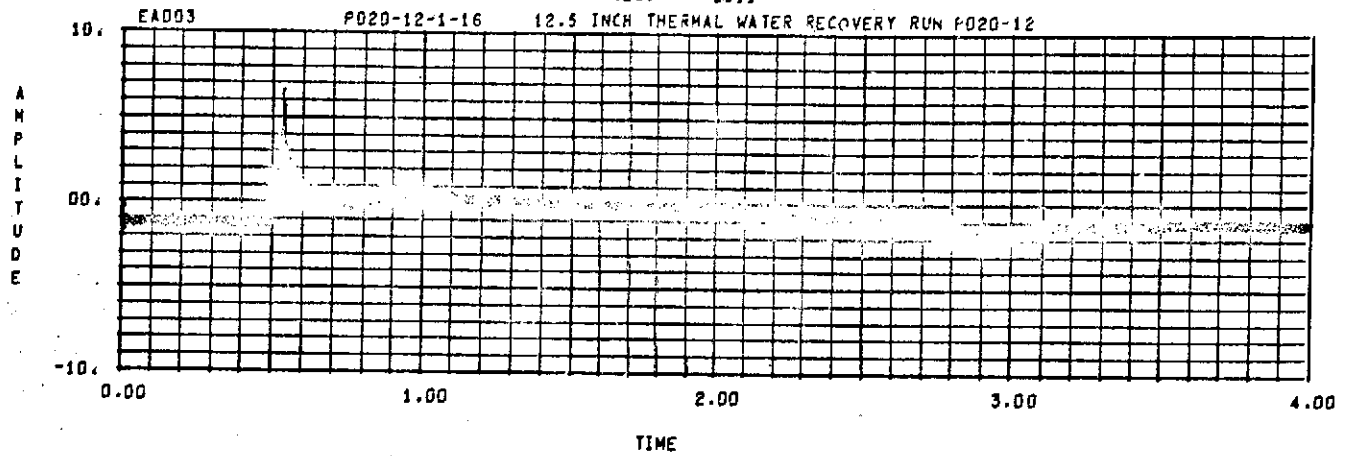


SEQ. = 0510

3

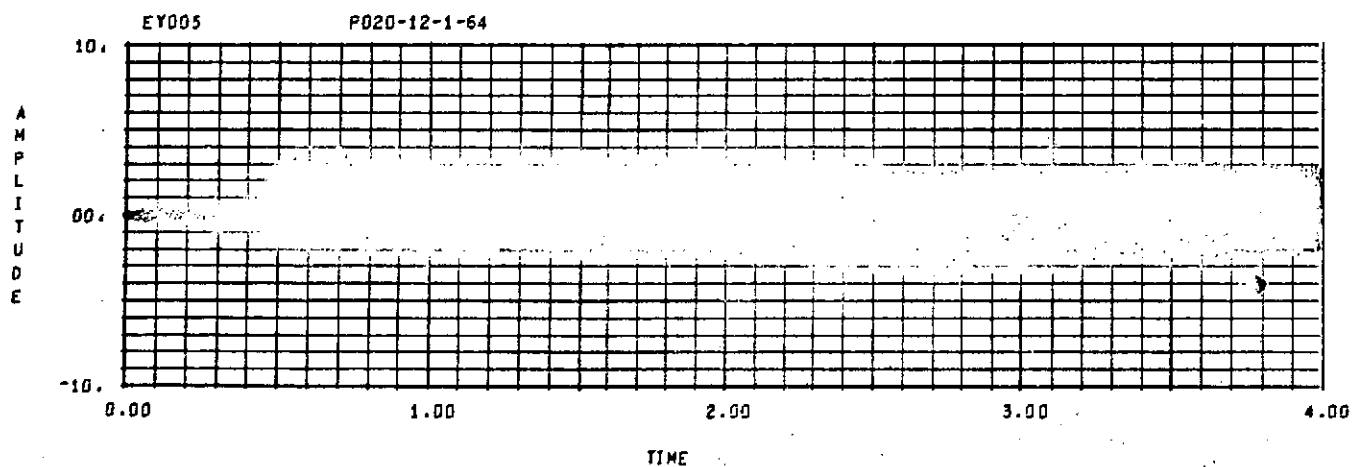
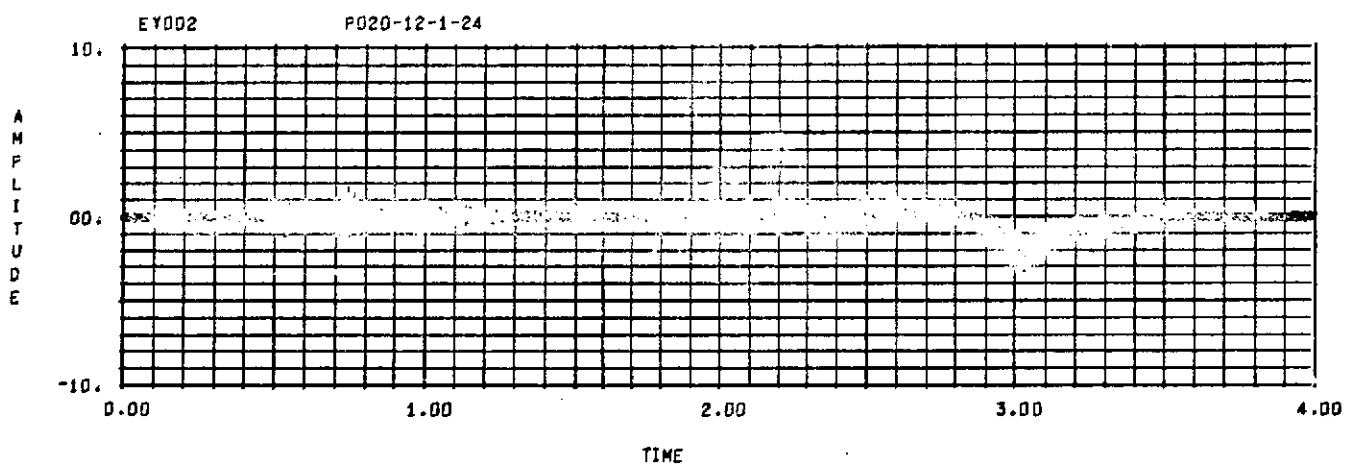
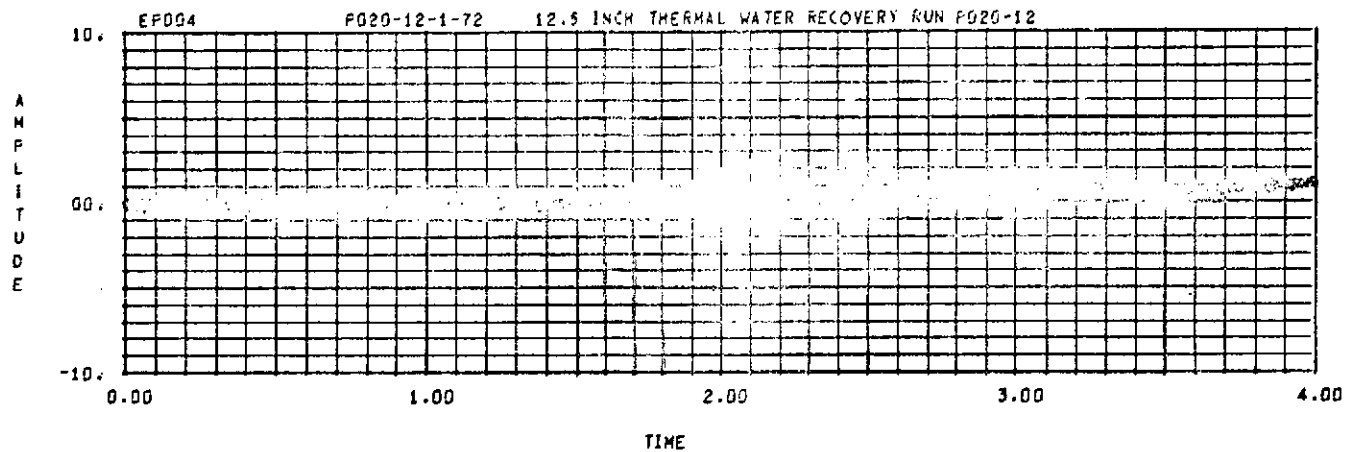


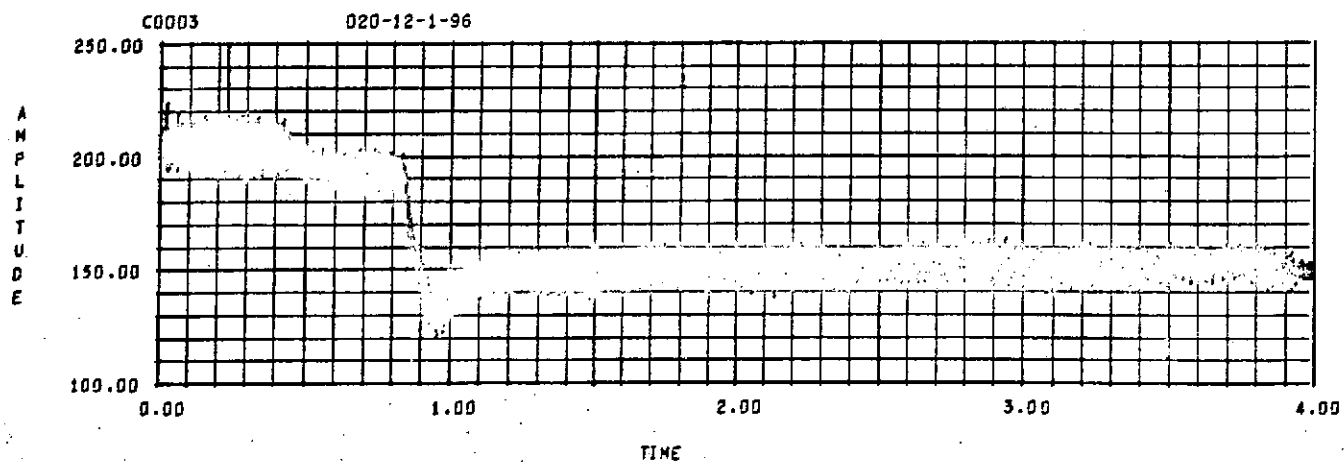
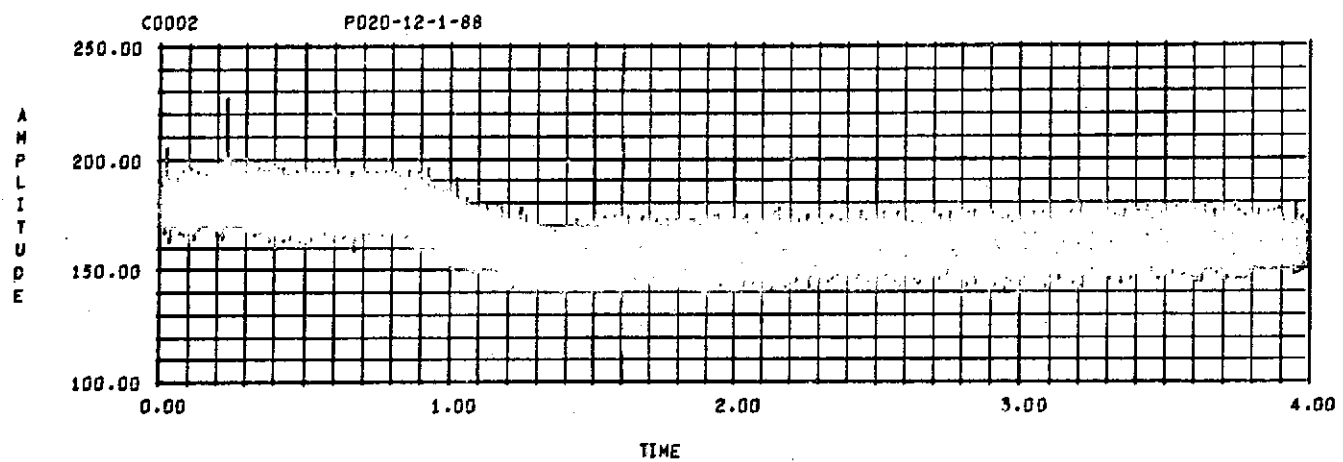
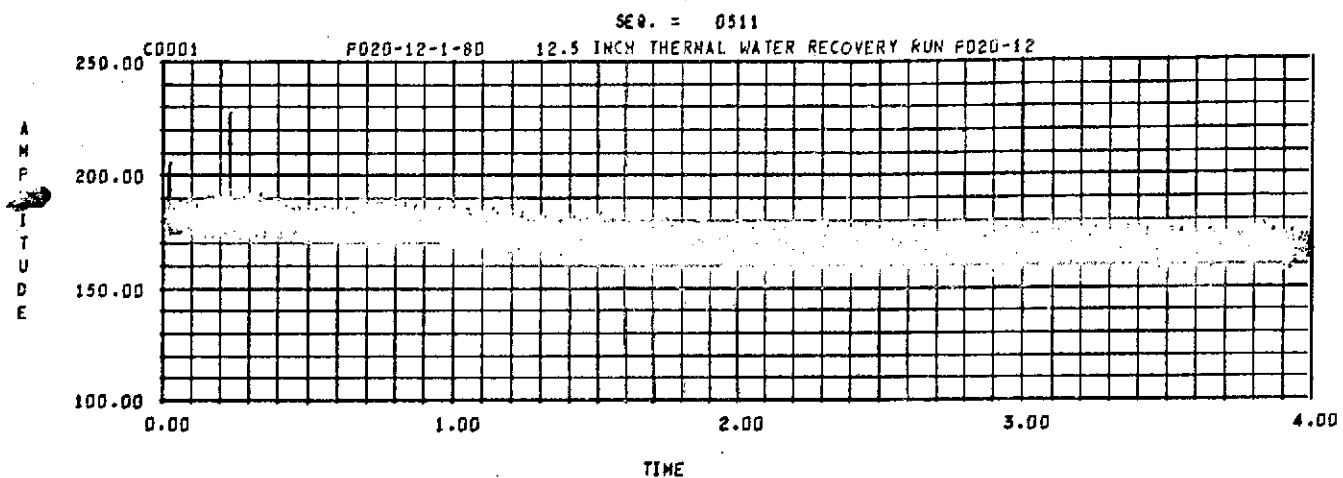
SEQ. = 0511



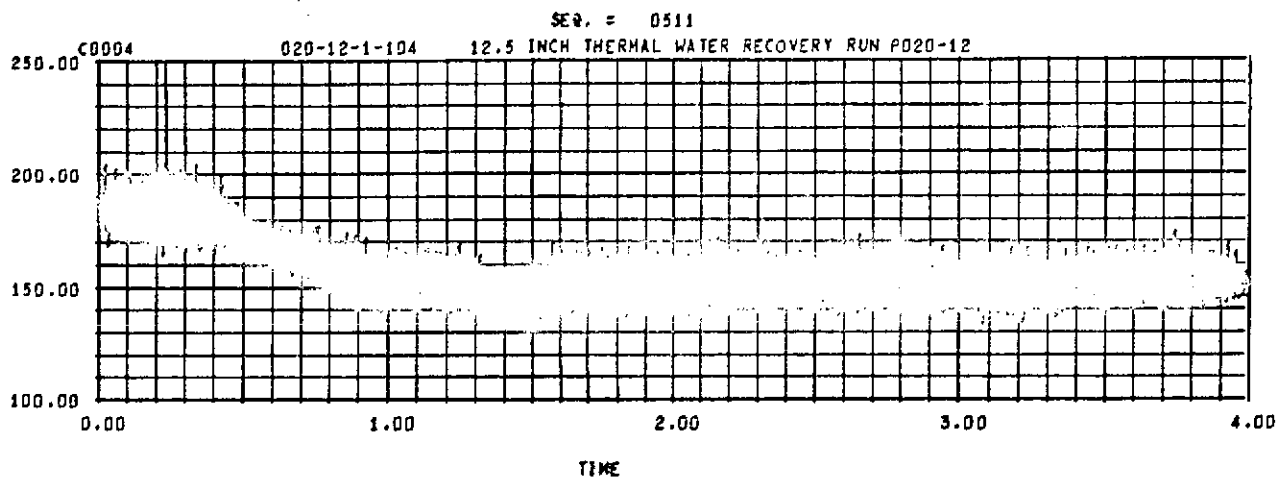
SEQ. = 0511

2

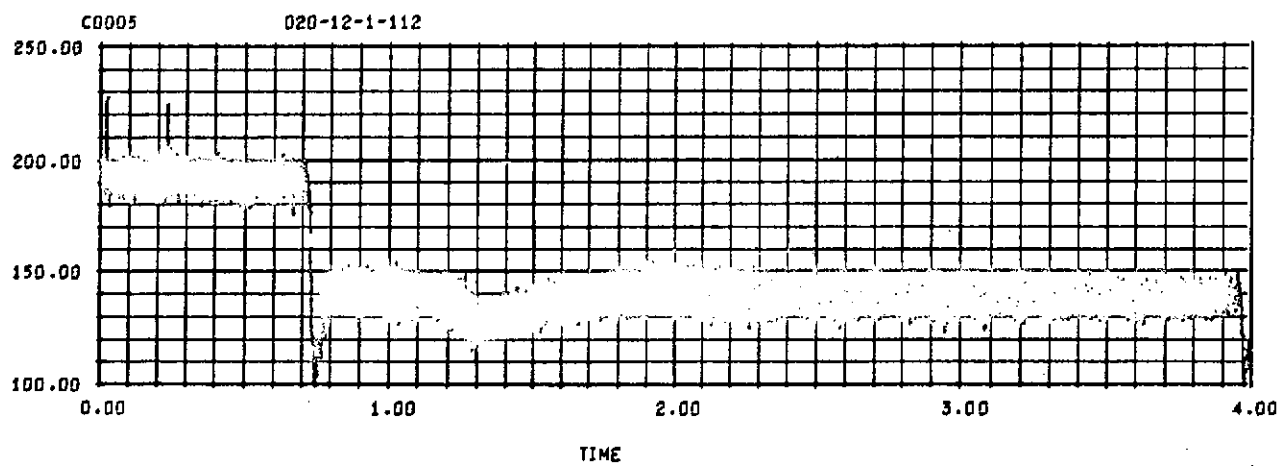




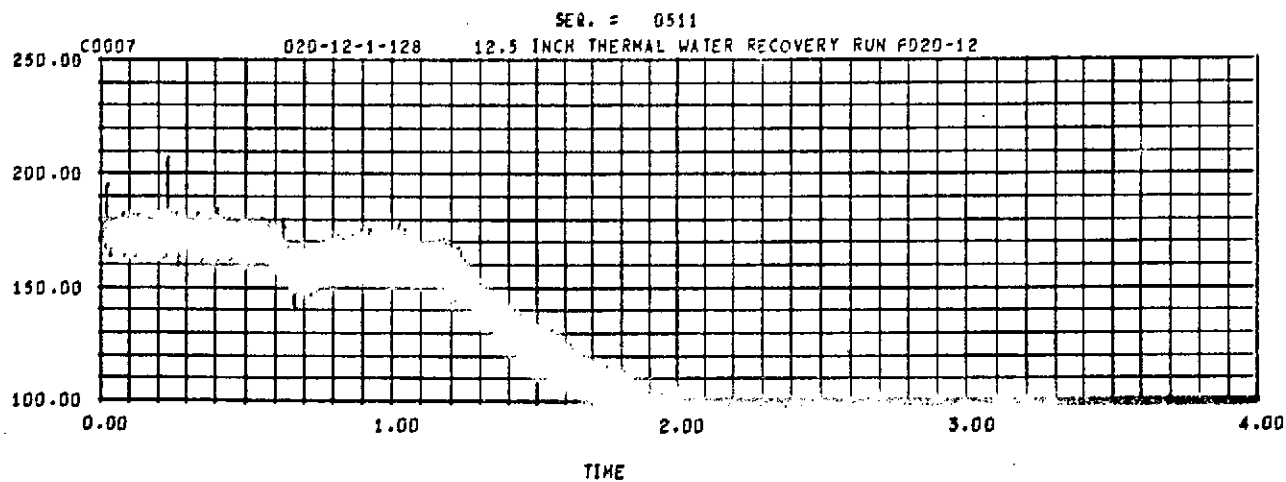
AMPLITUDE

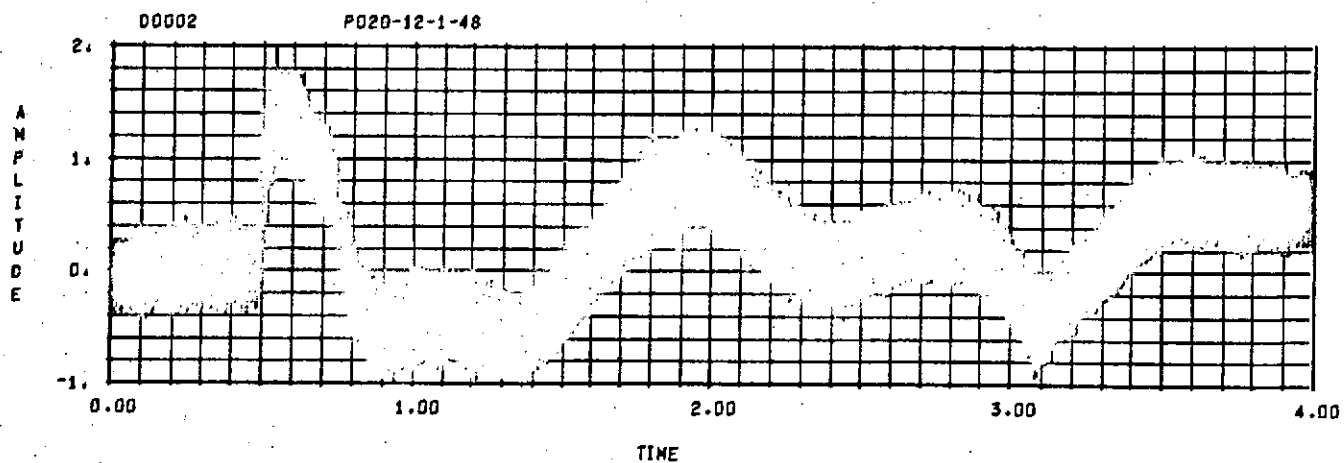
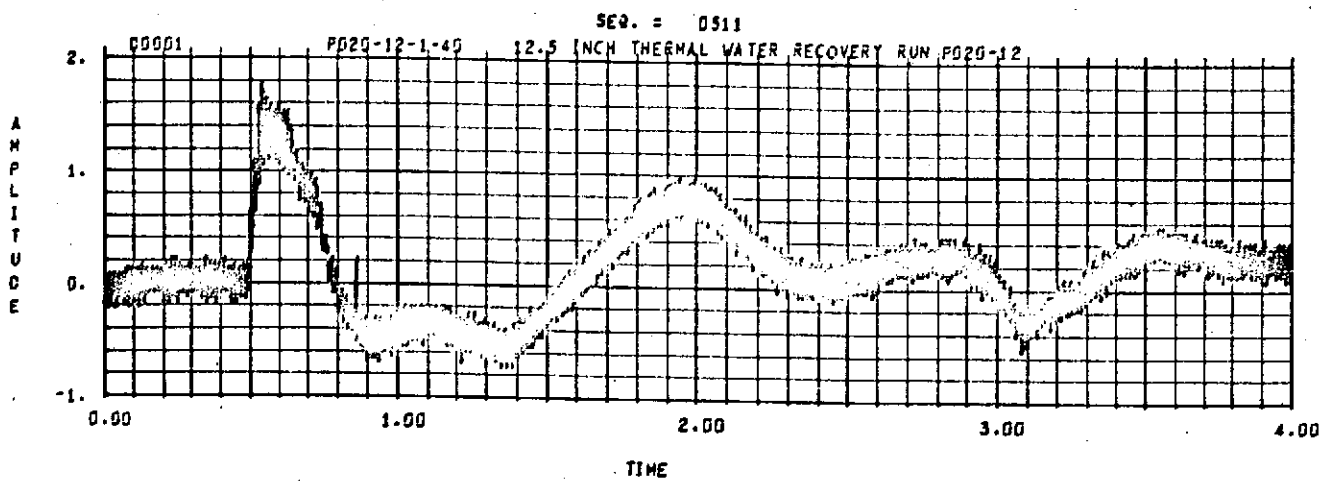
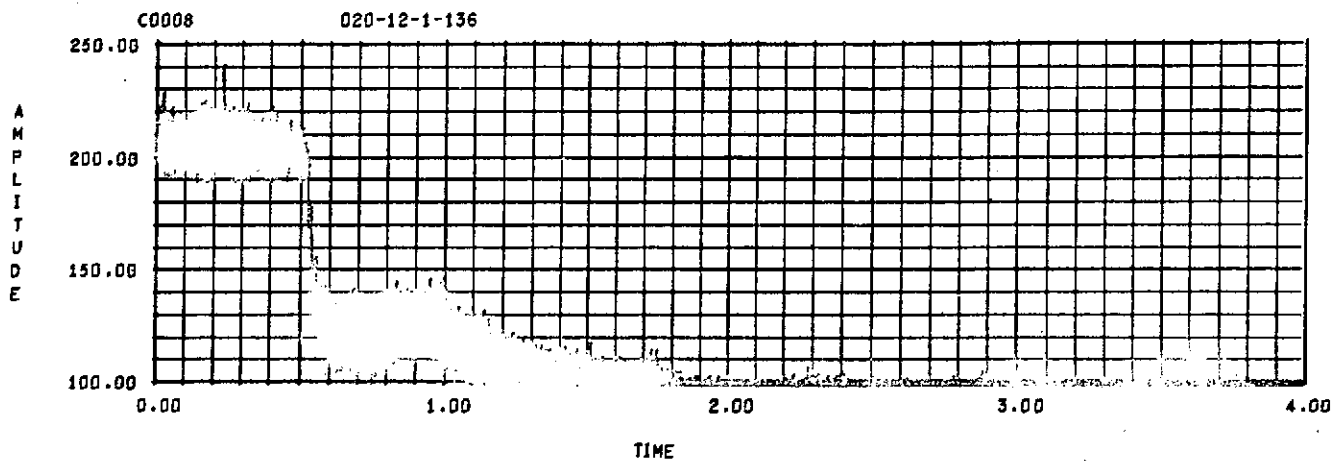


AMPLITUDE



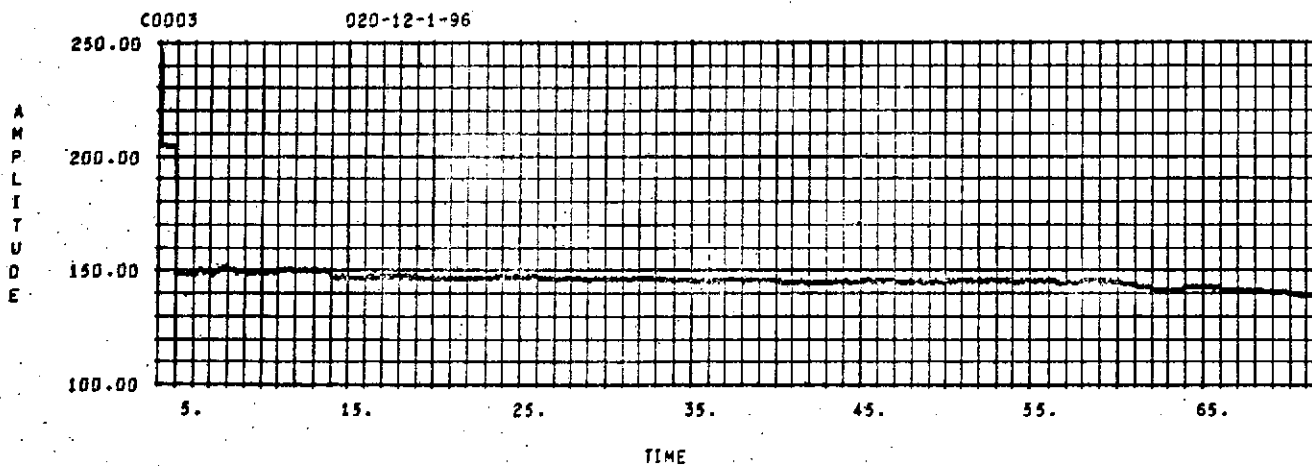
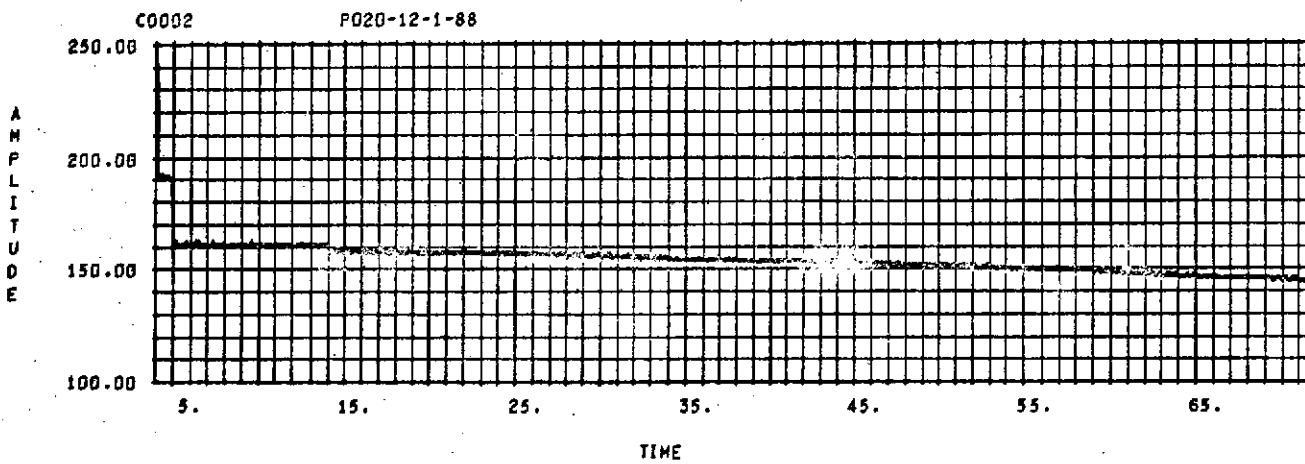
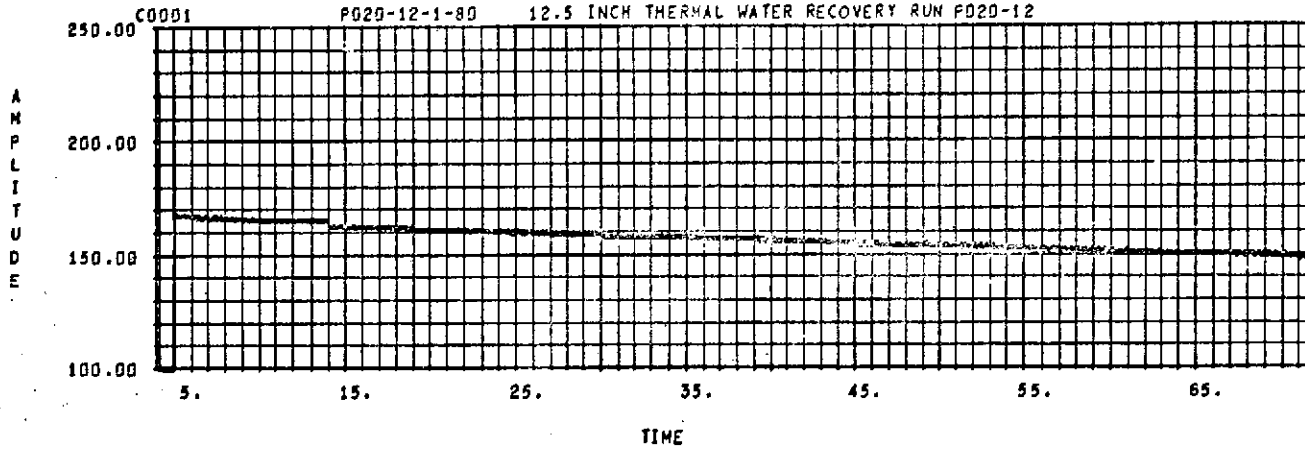
AMPLITUDE

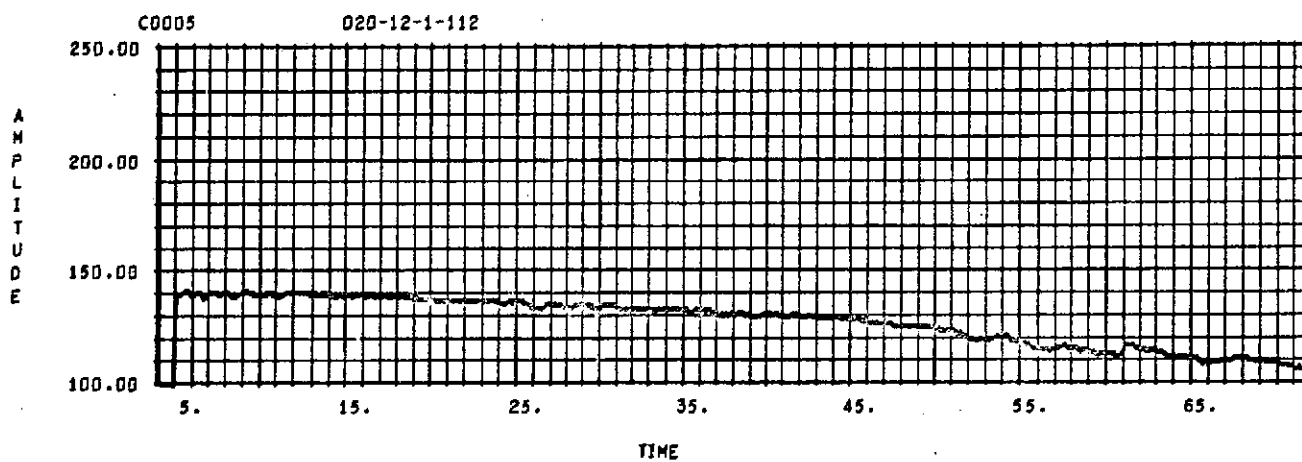
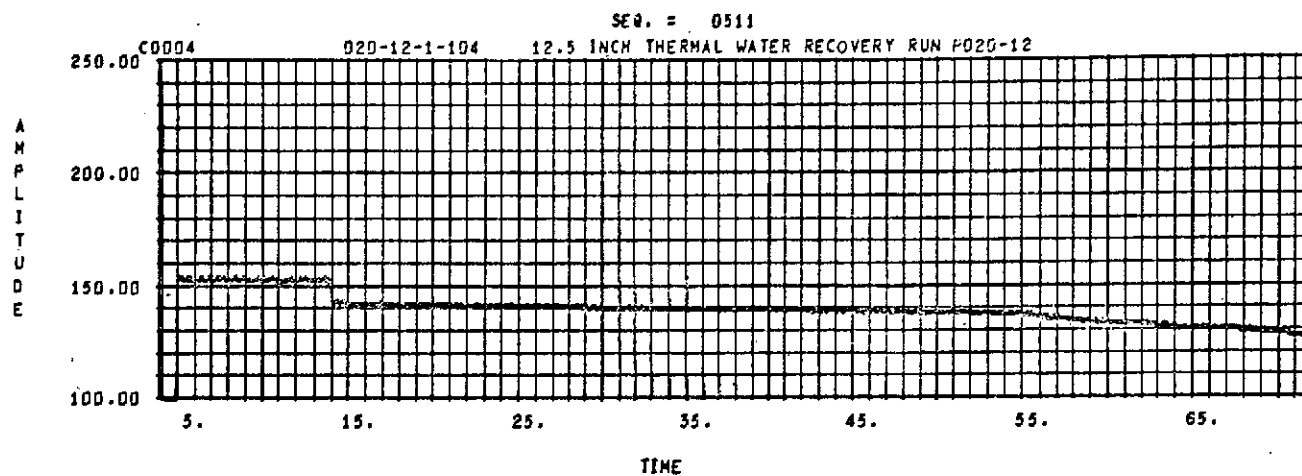




SEQ. = 0511

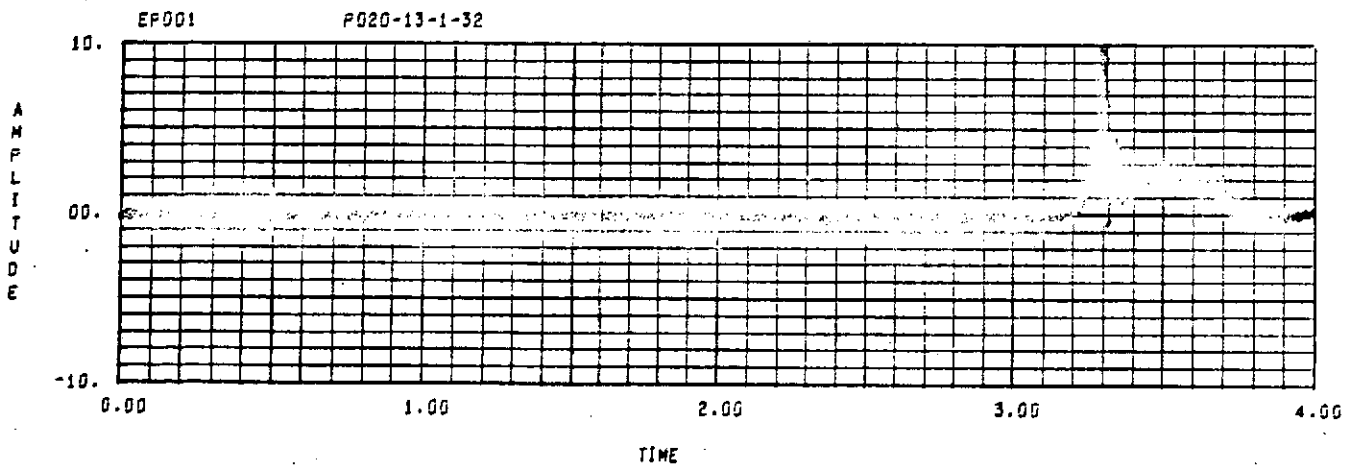
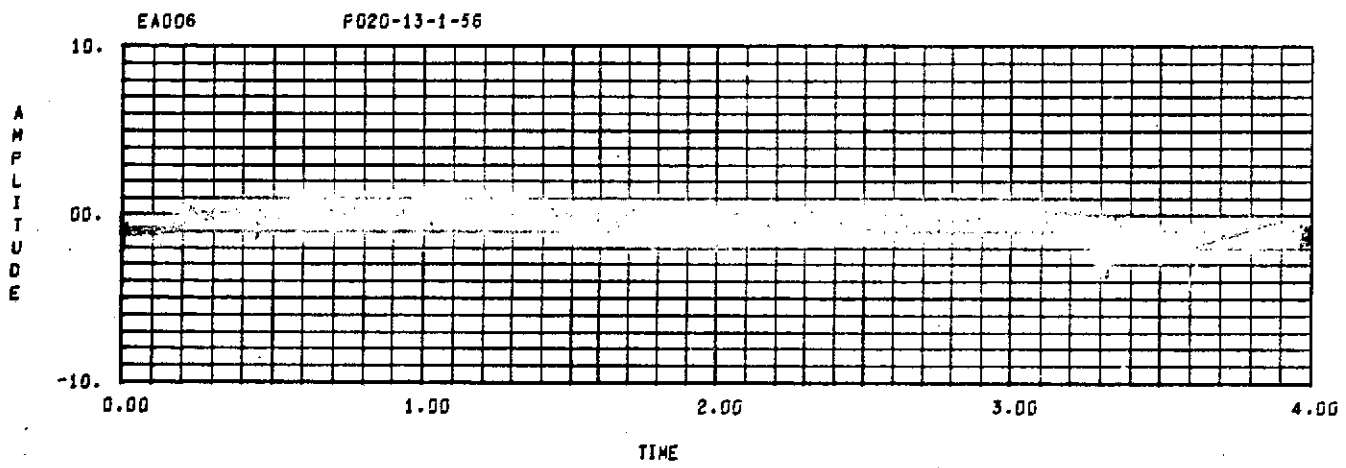
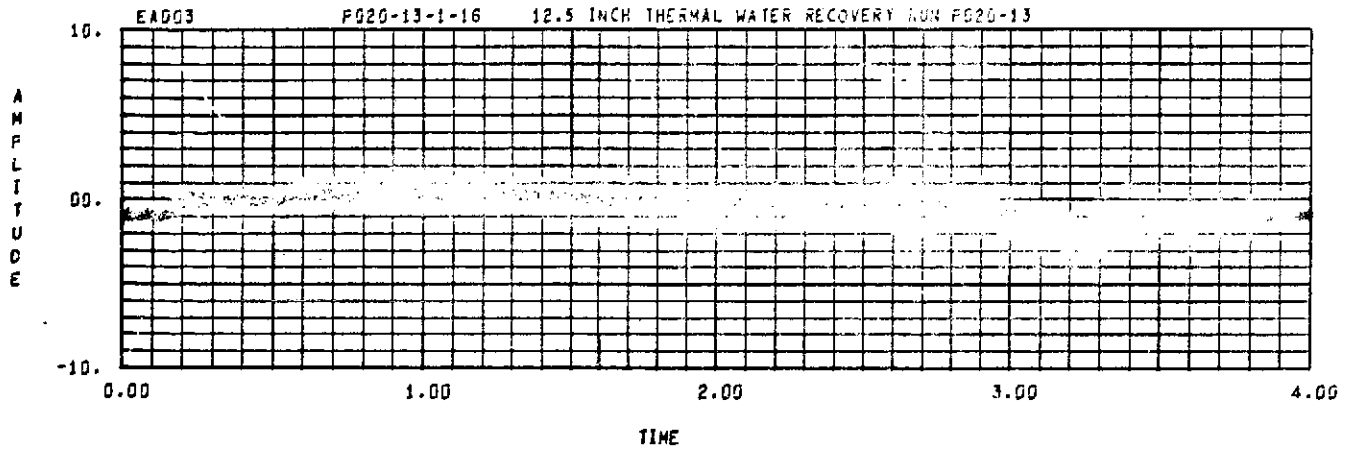
11

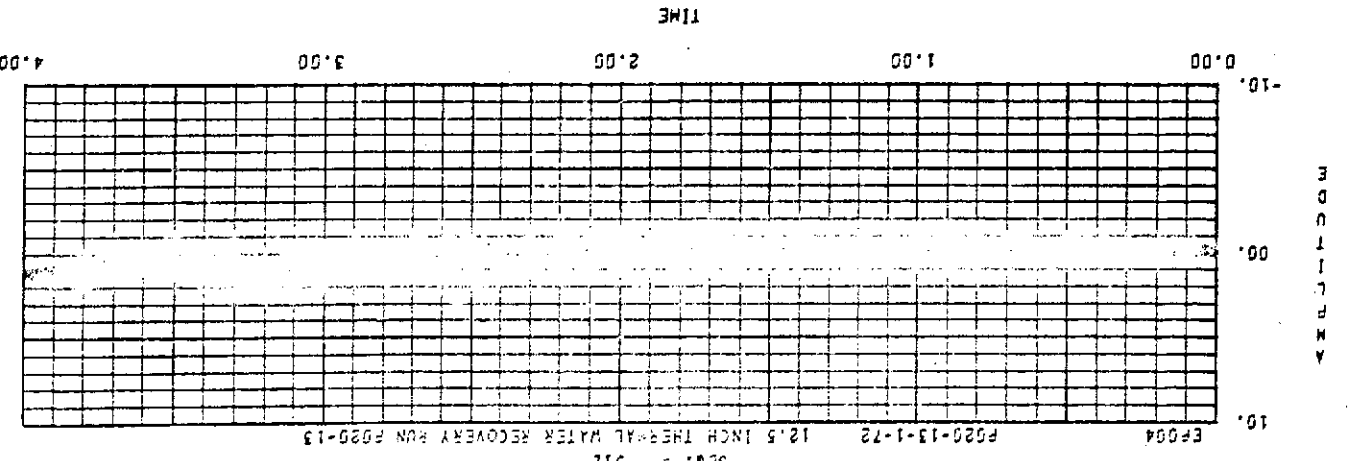
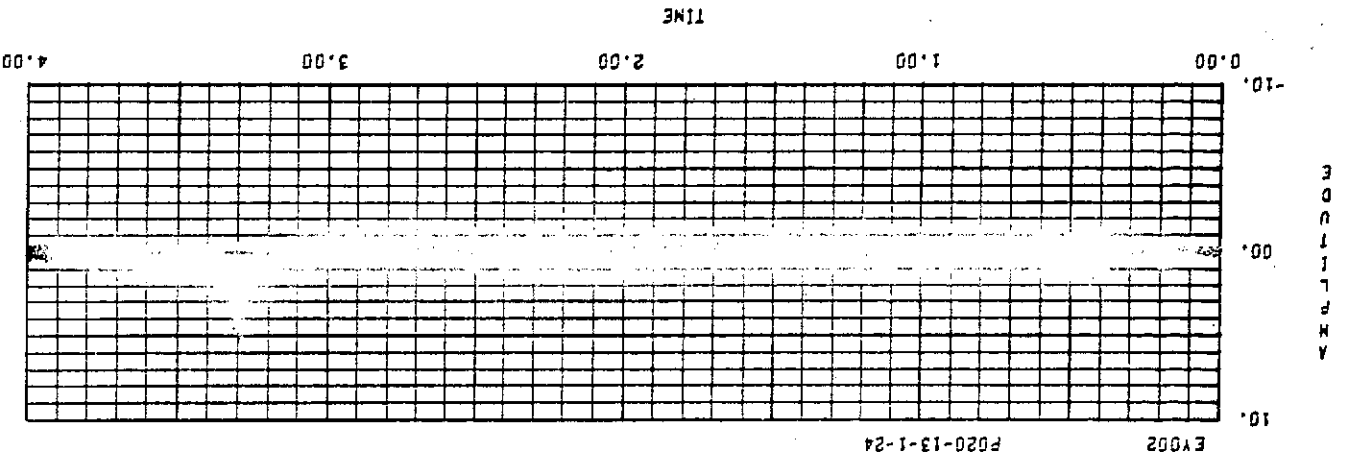
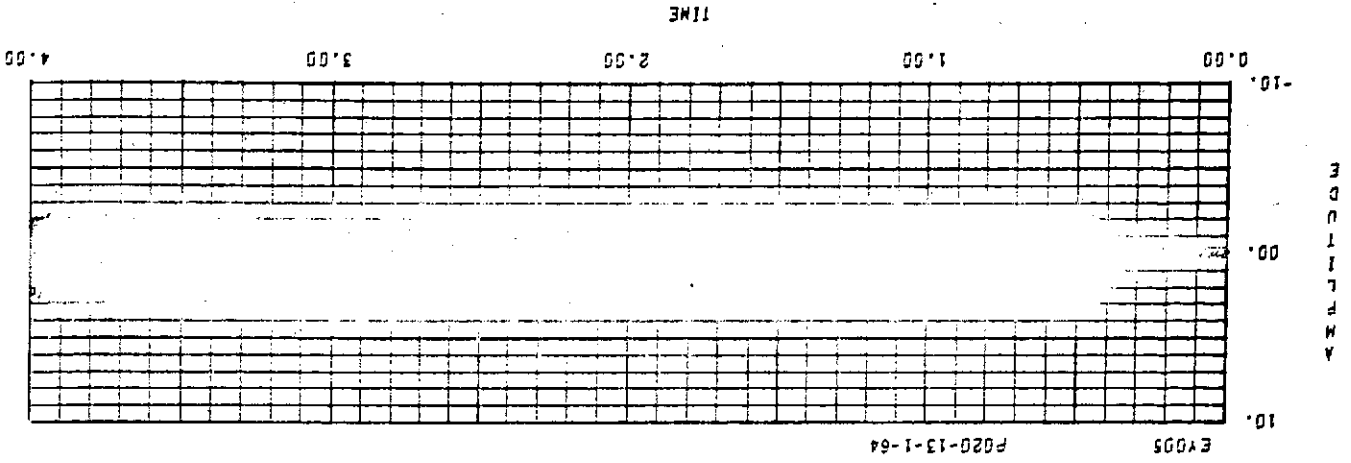




SEQ. = 512

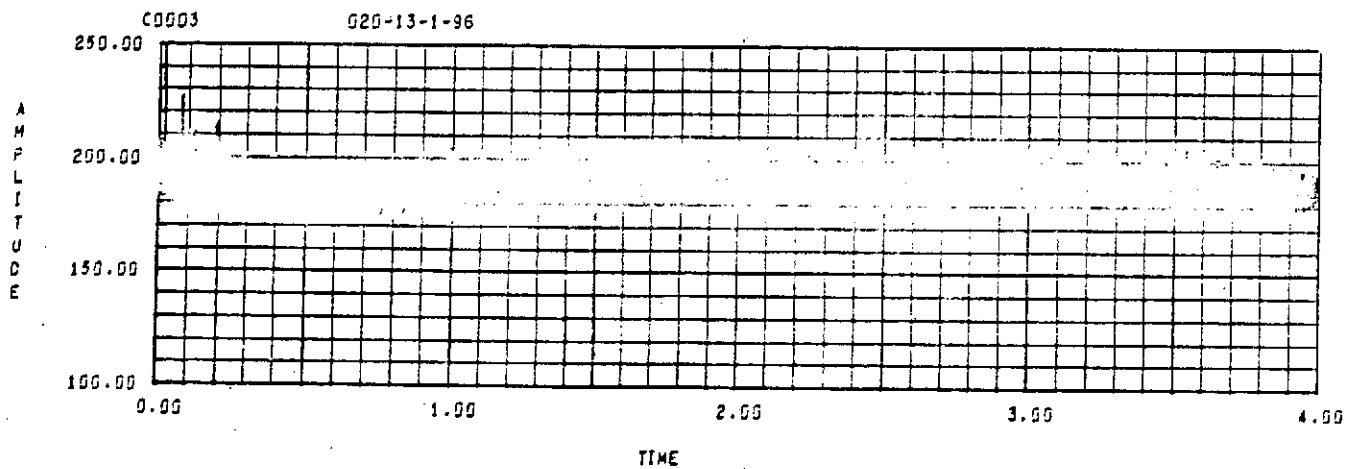
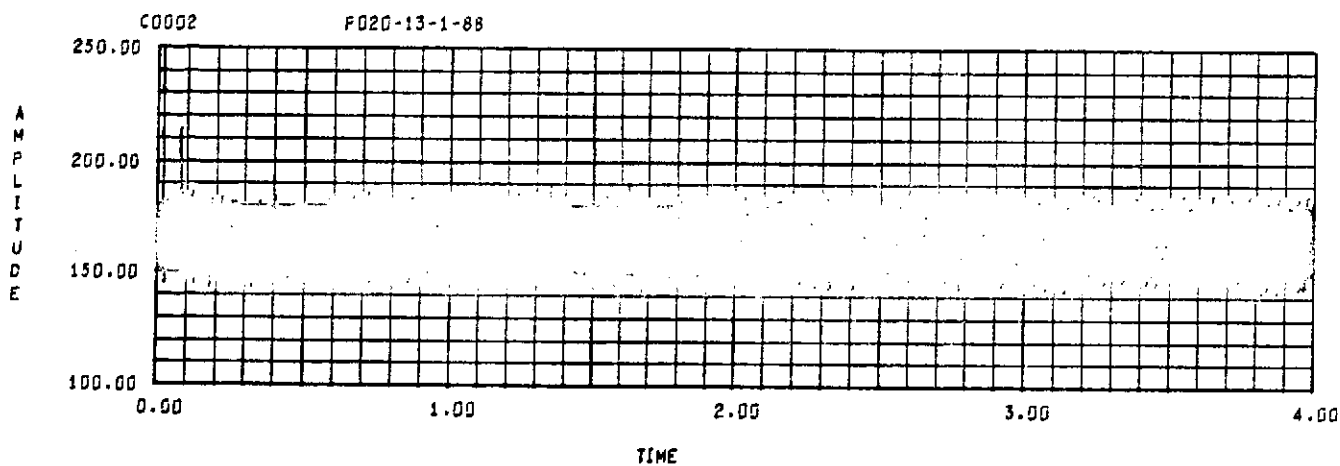
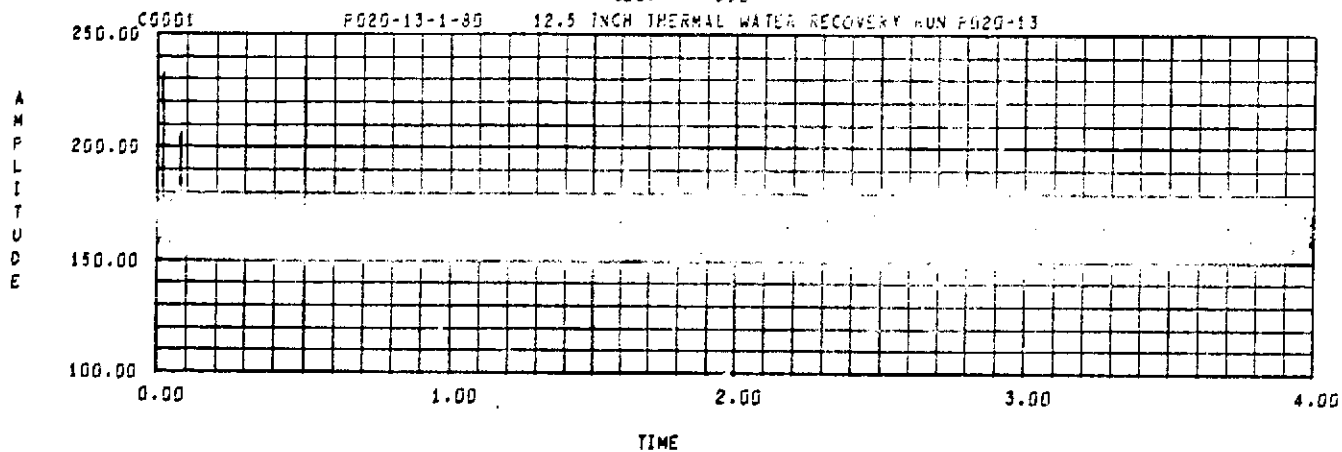
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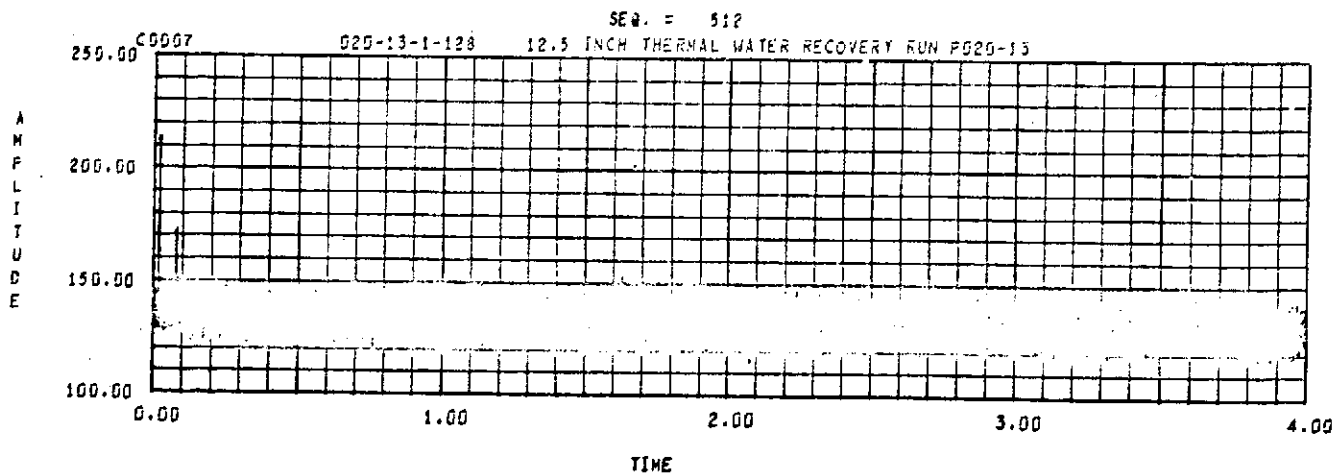
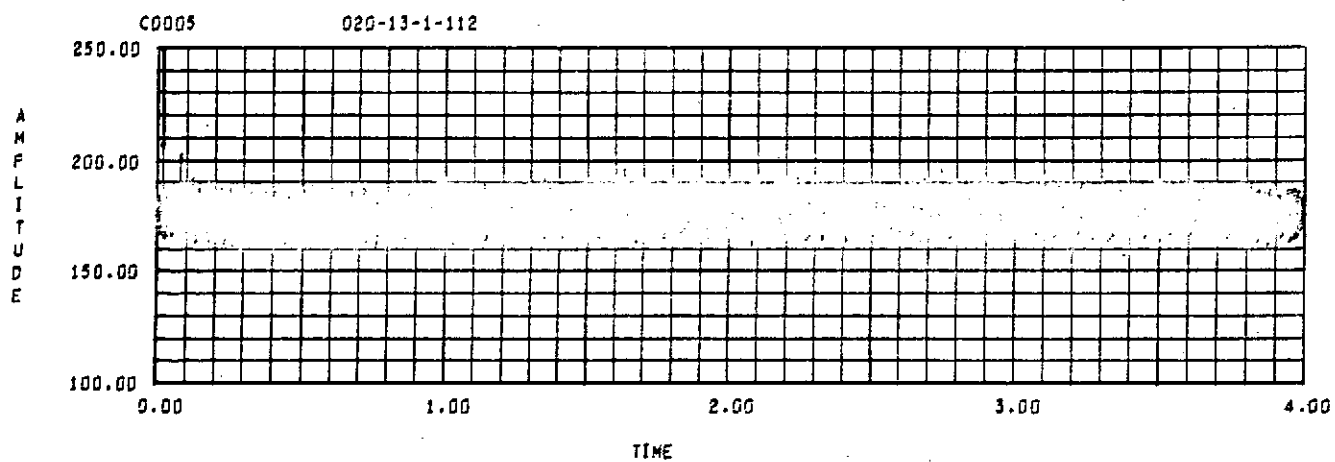
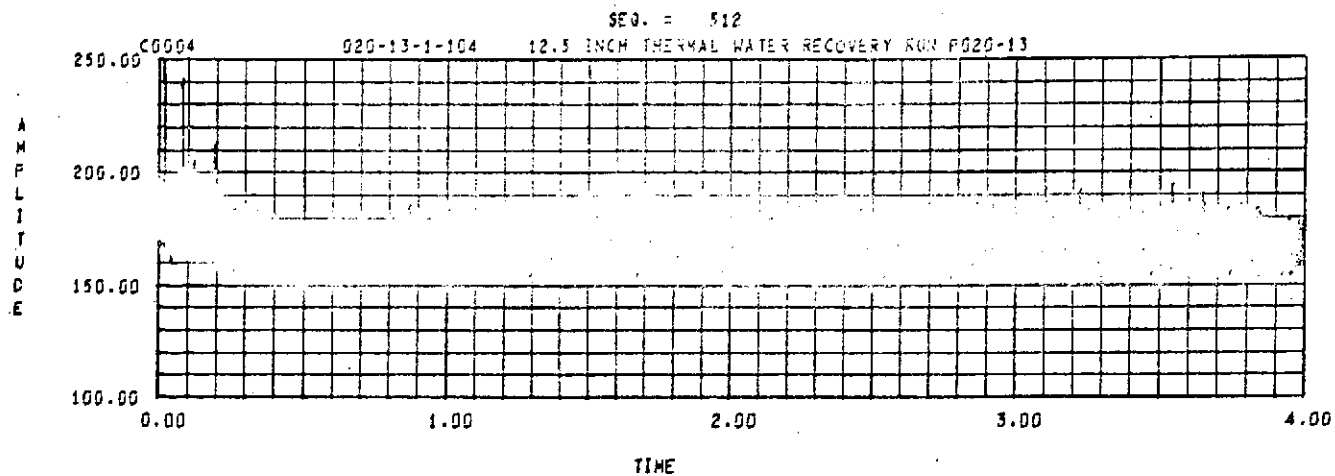


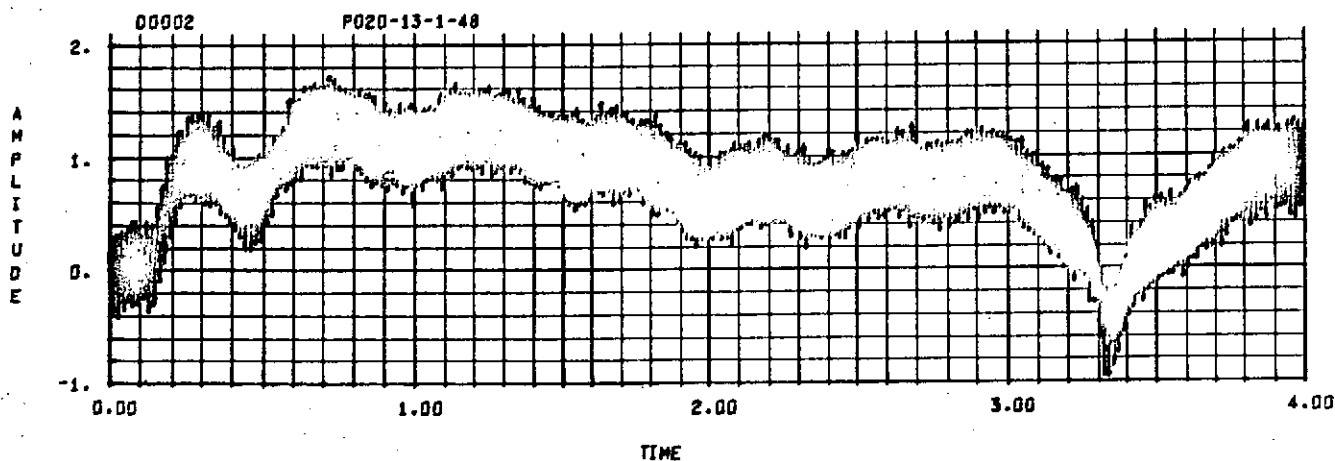
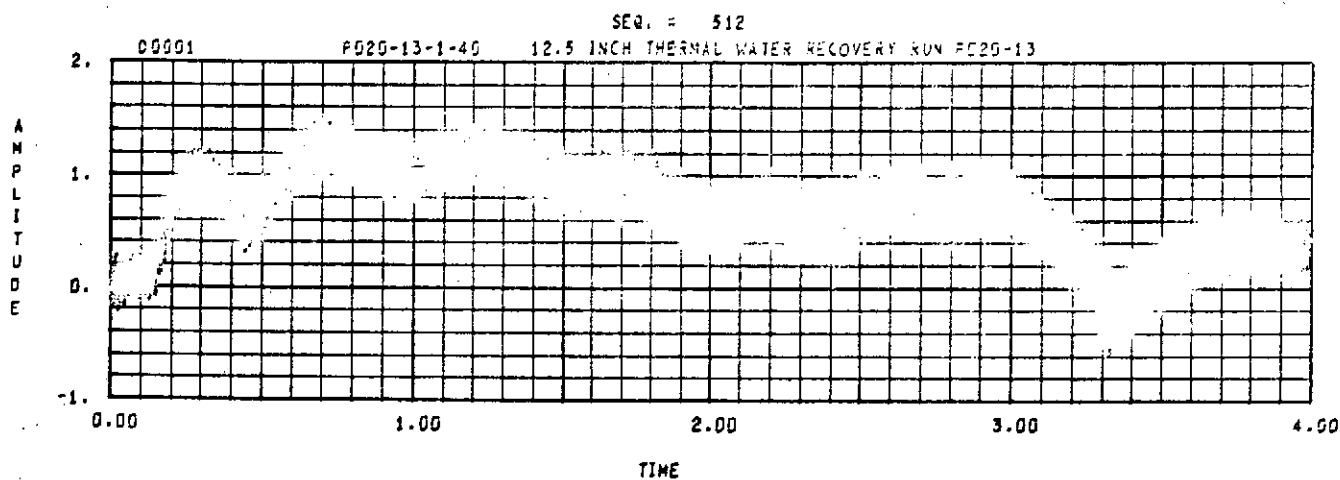
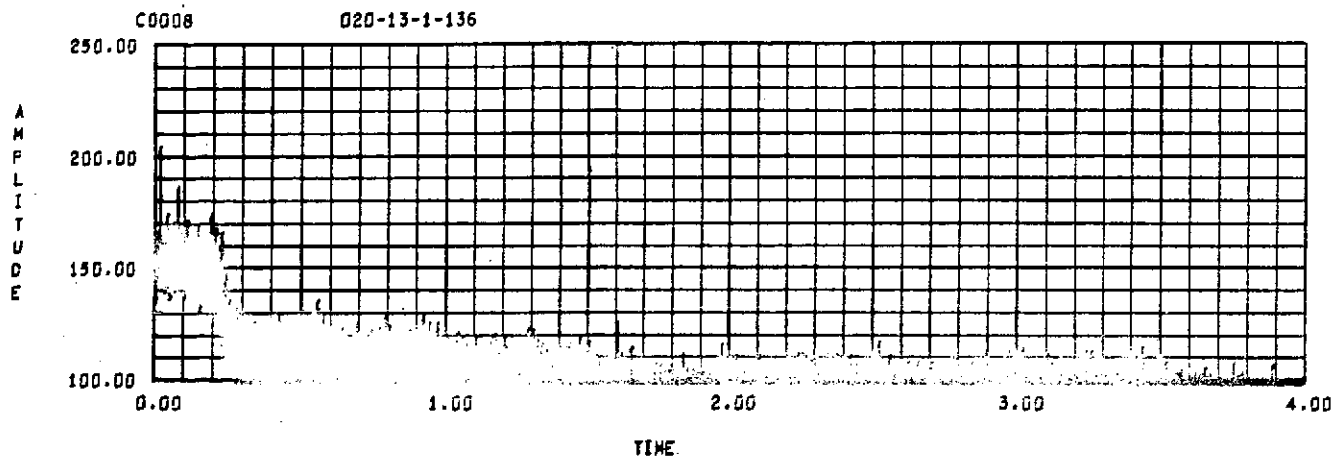


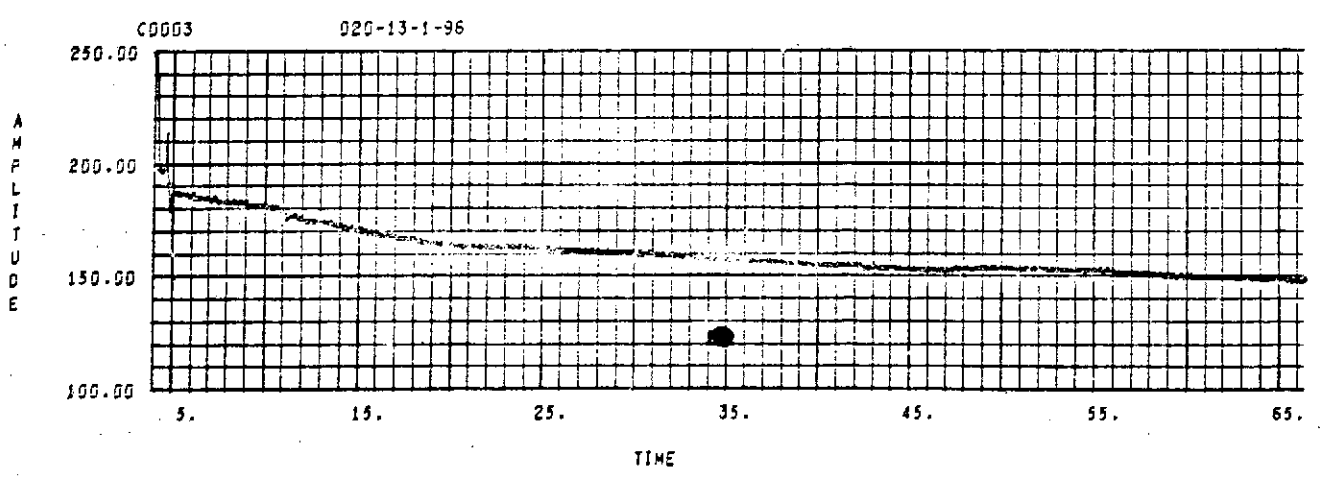
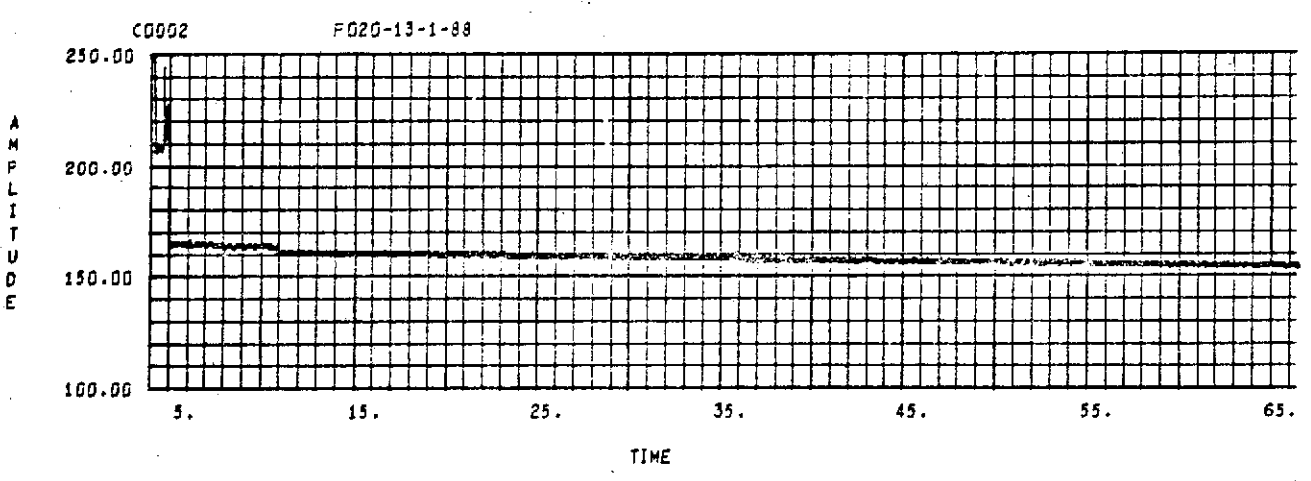
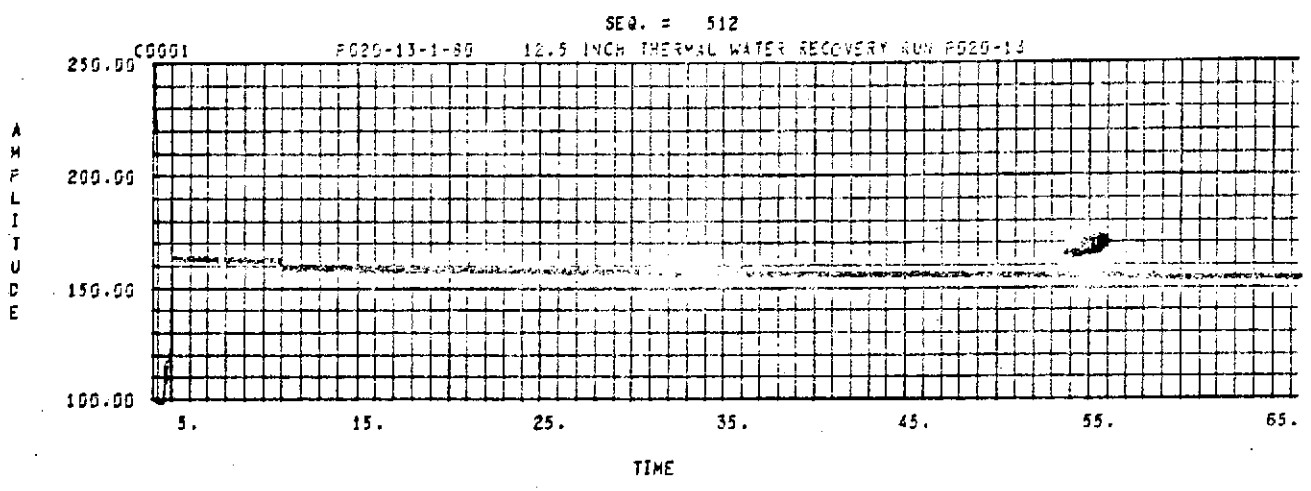
SEA. = 512

3

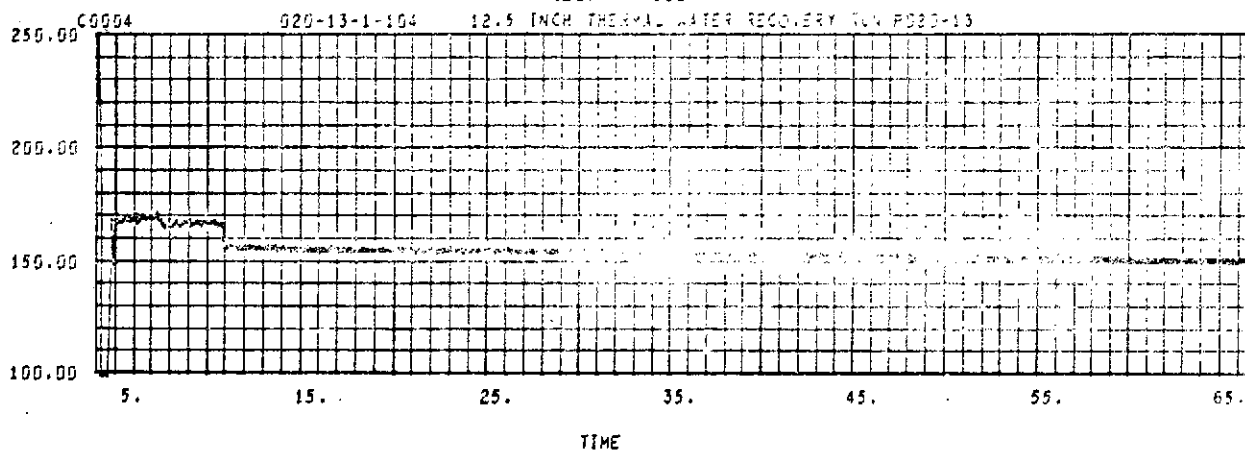




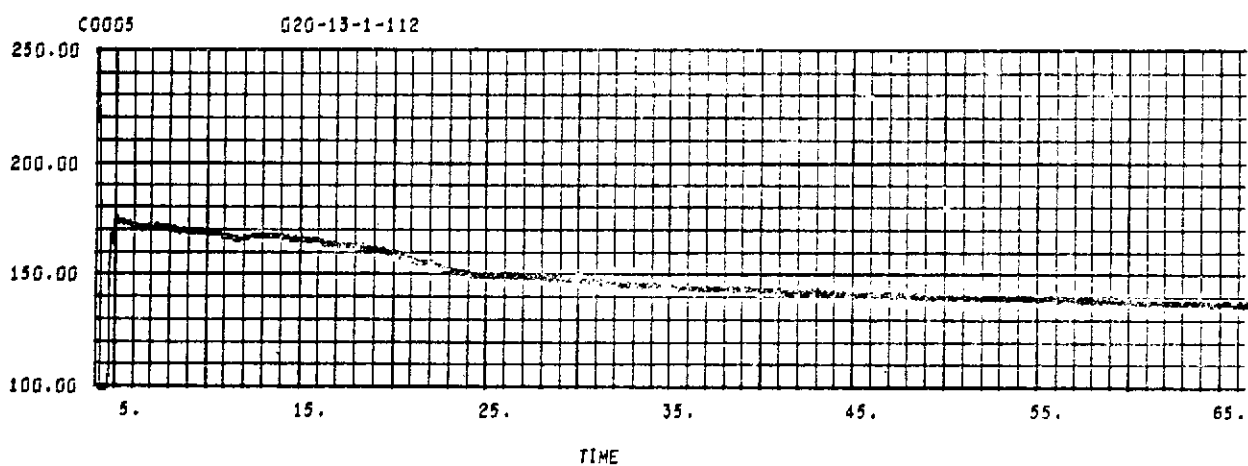




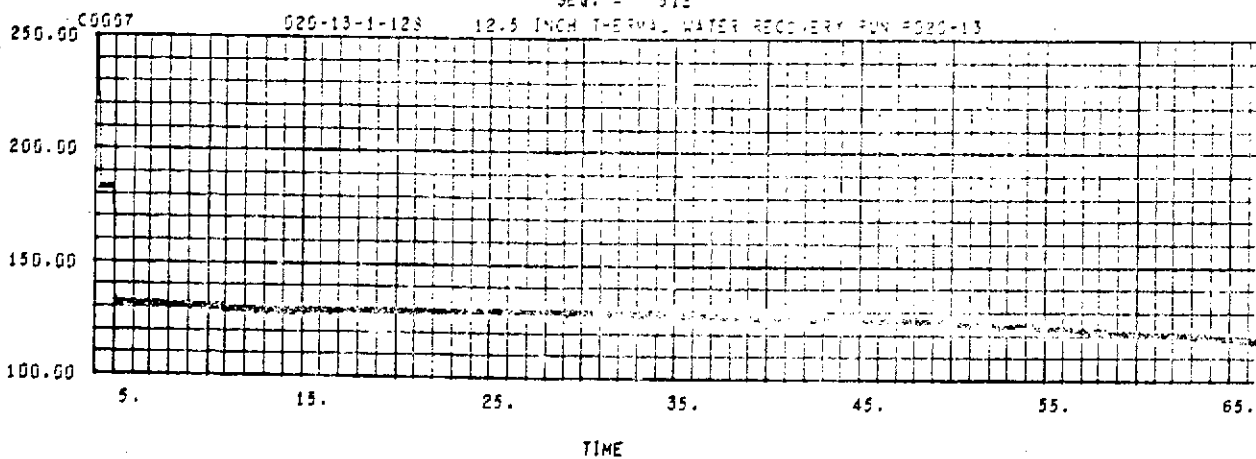
SEQ. = 512

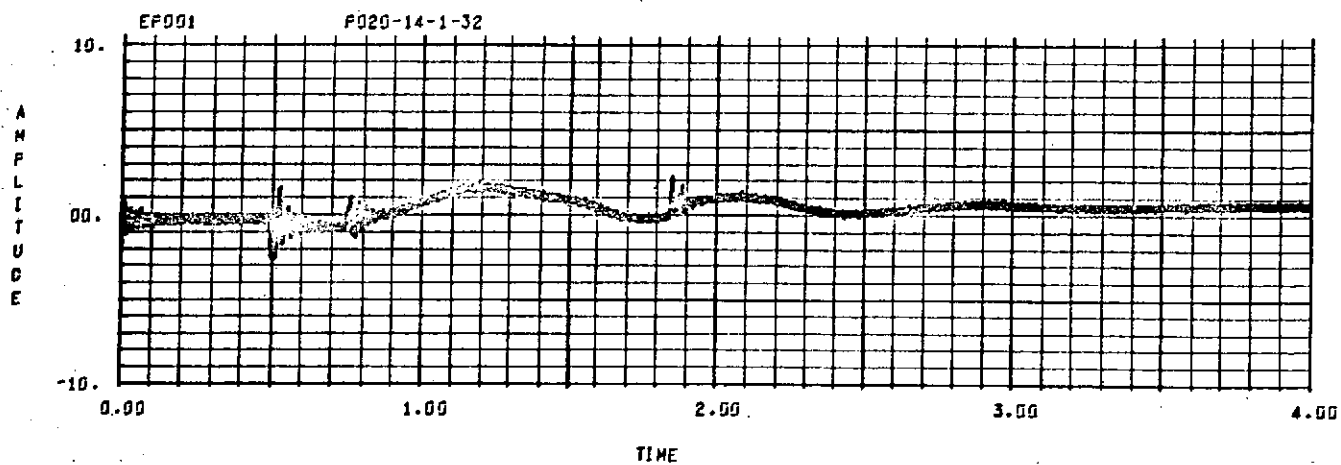
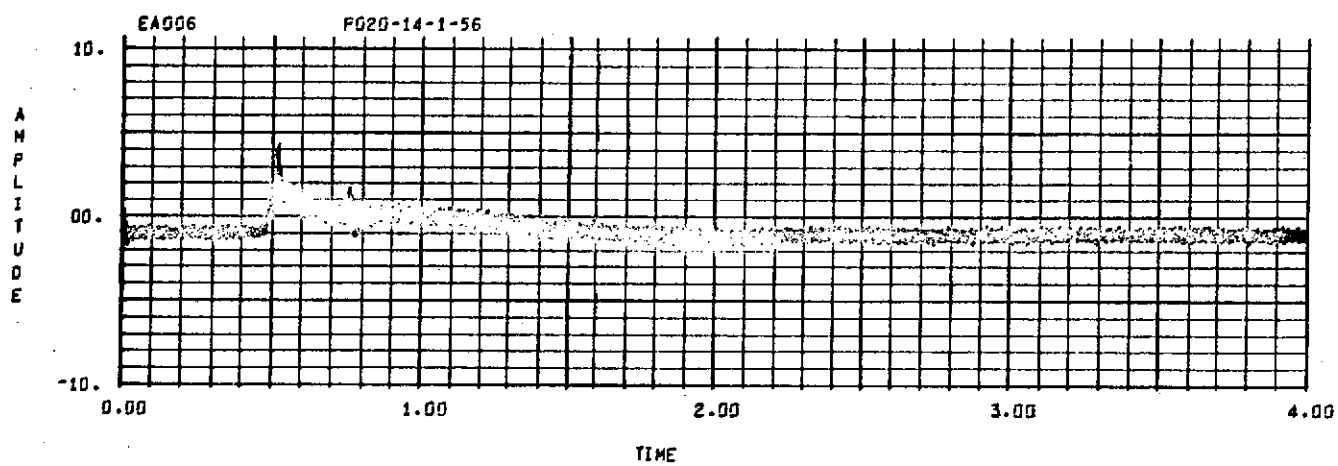
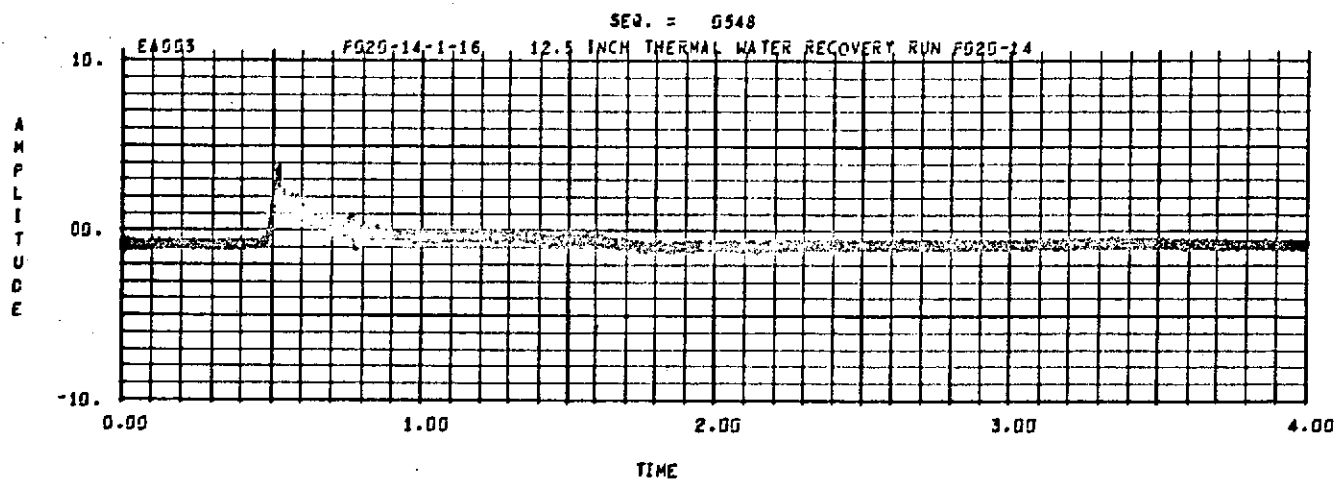


AMPLITUDE



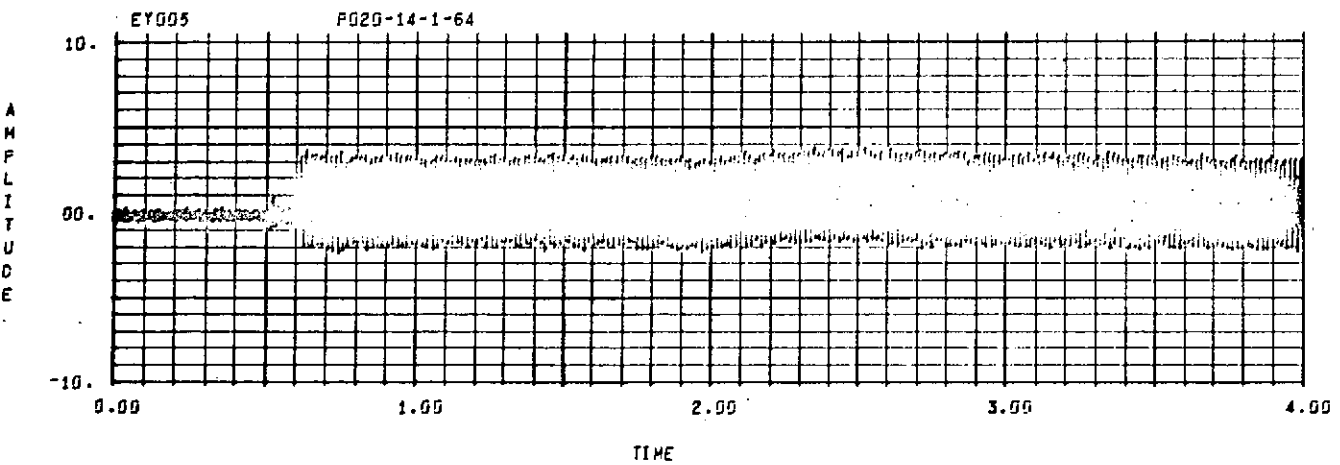
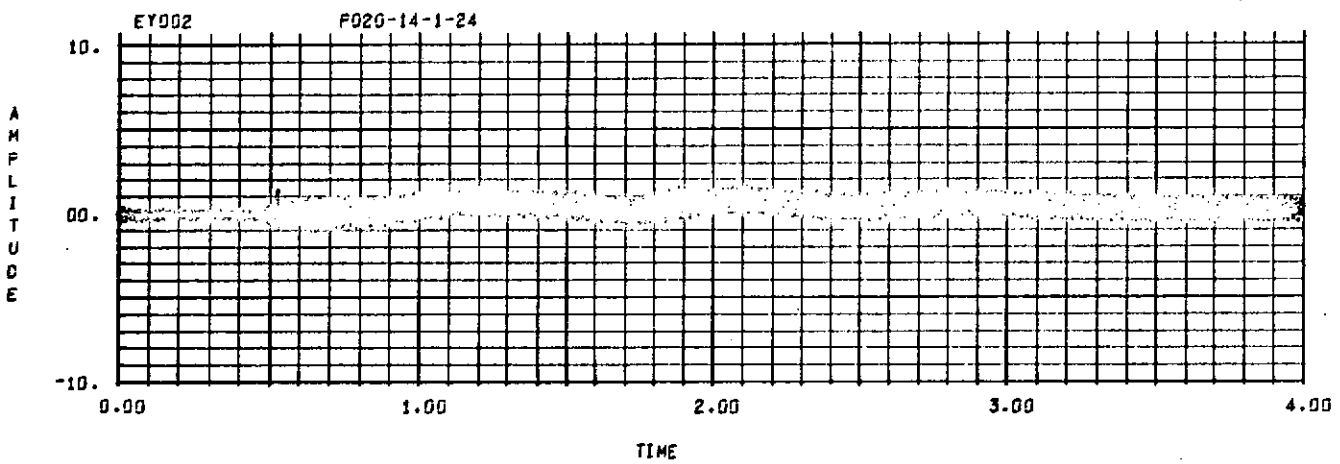
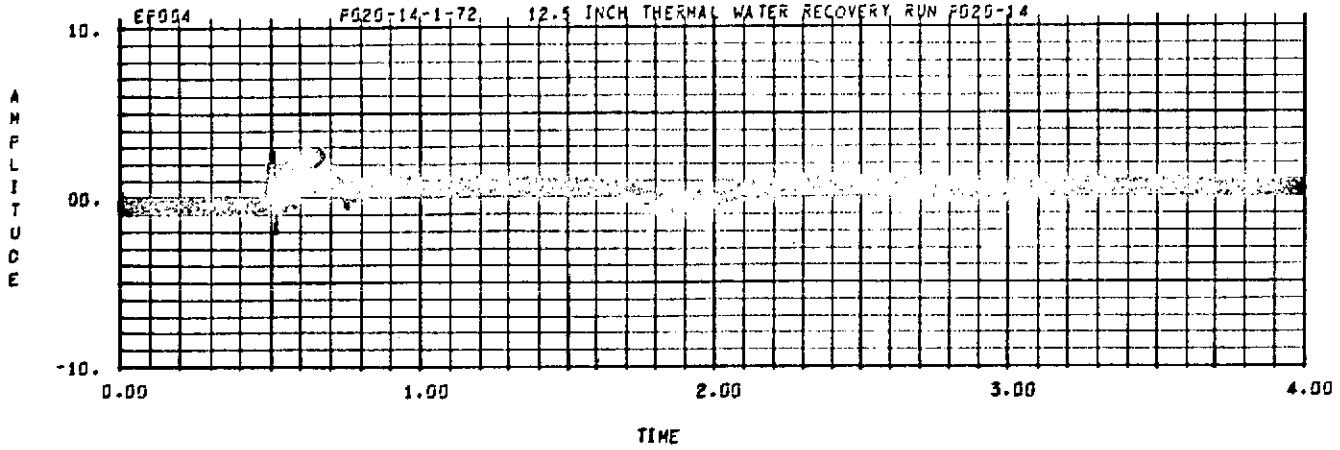
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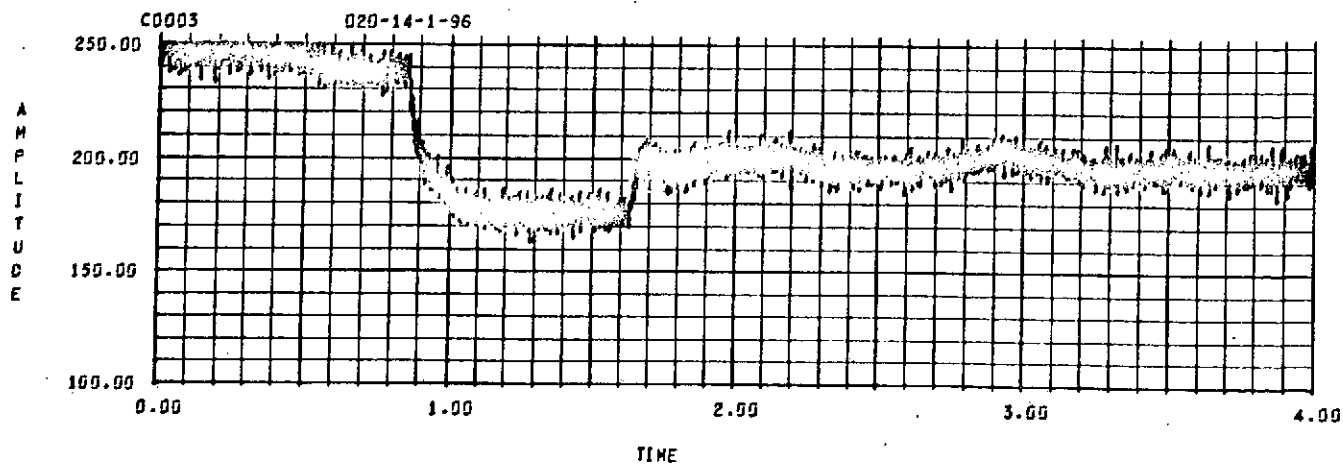
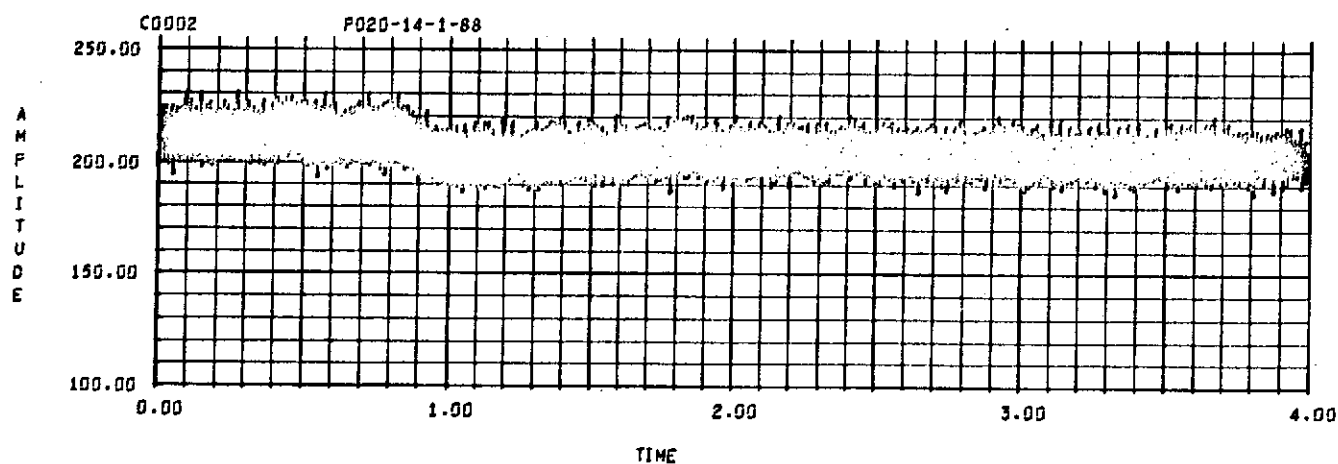
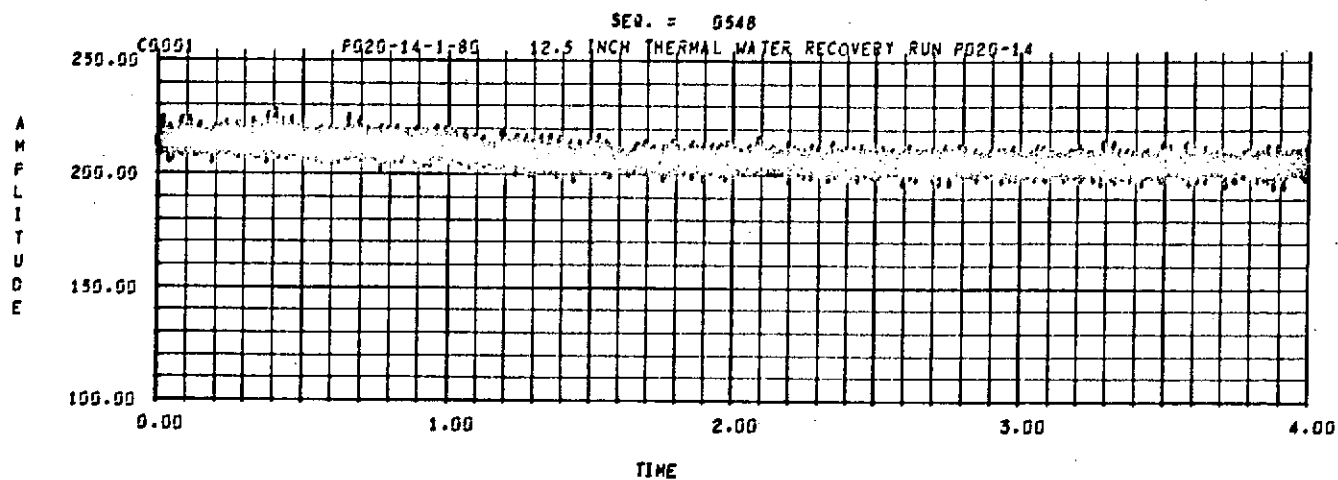




SEQ. = 0548

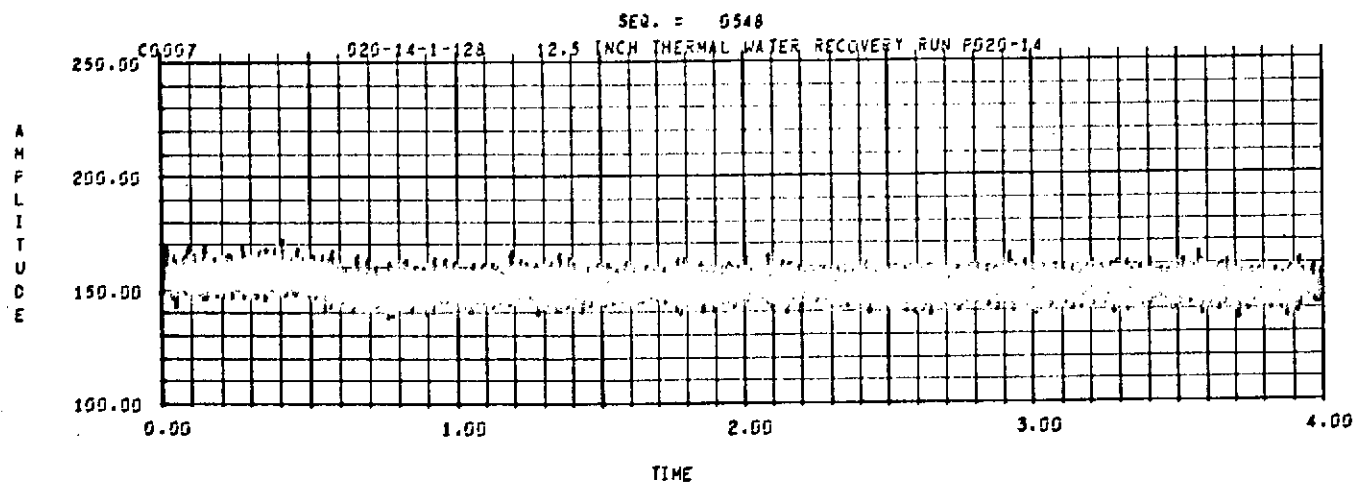
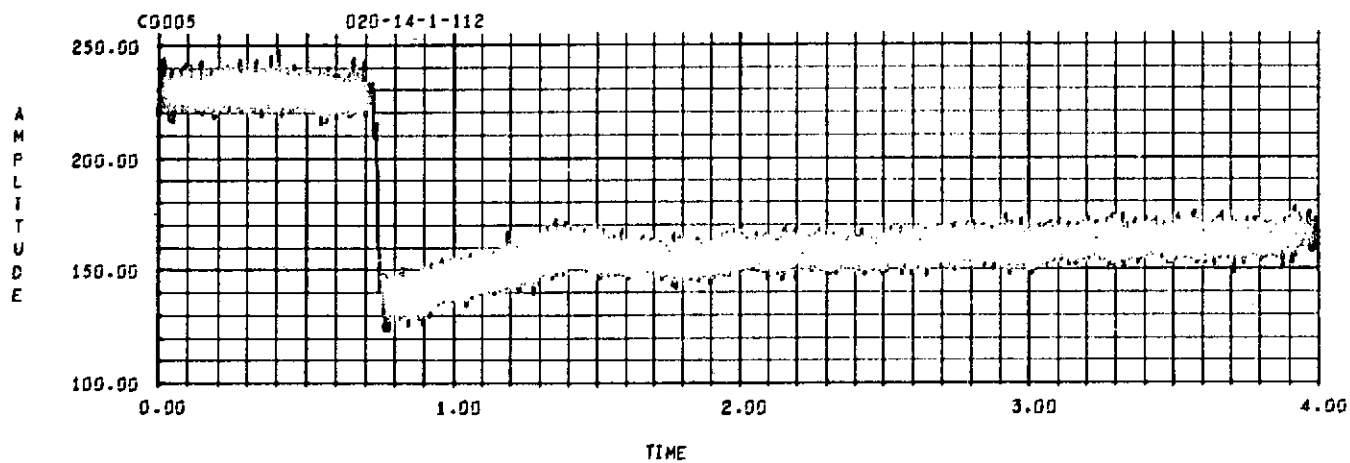
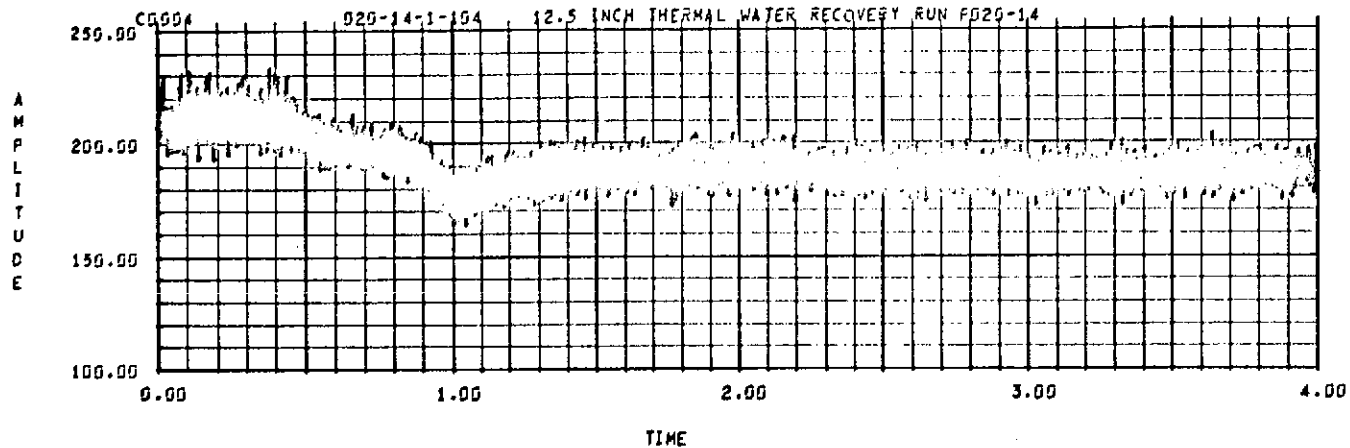
2

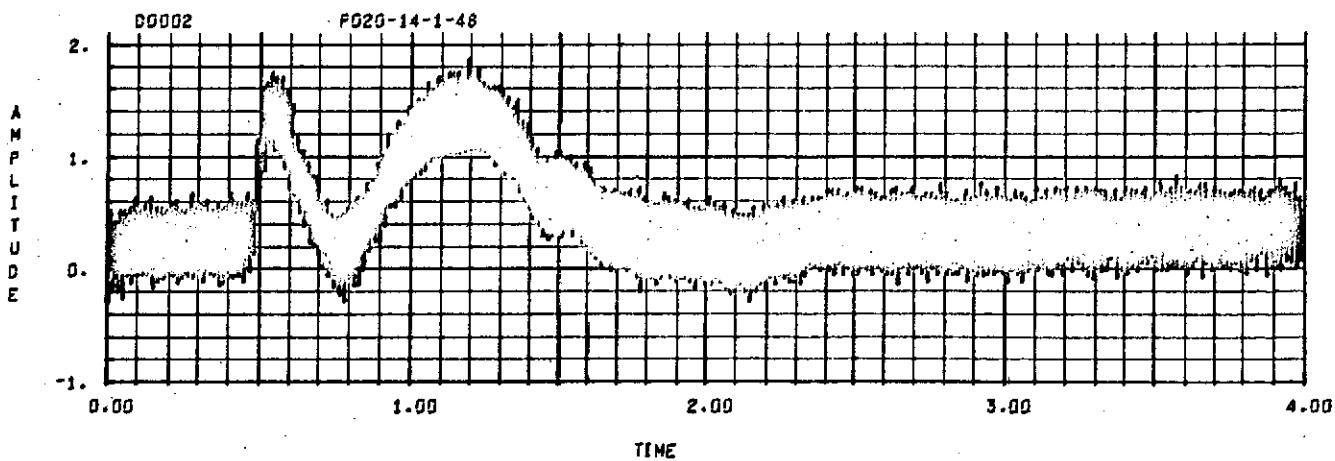
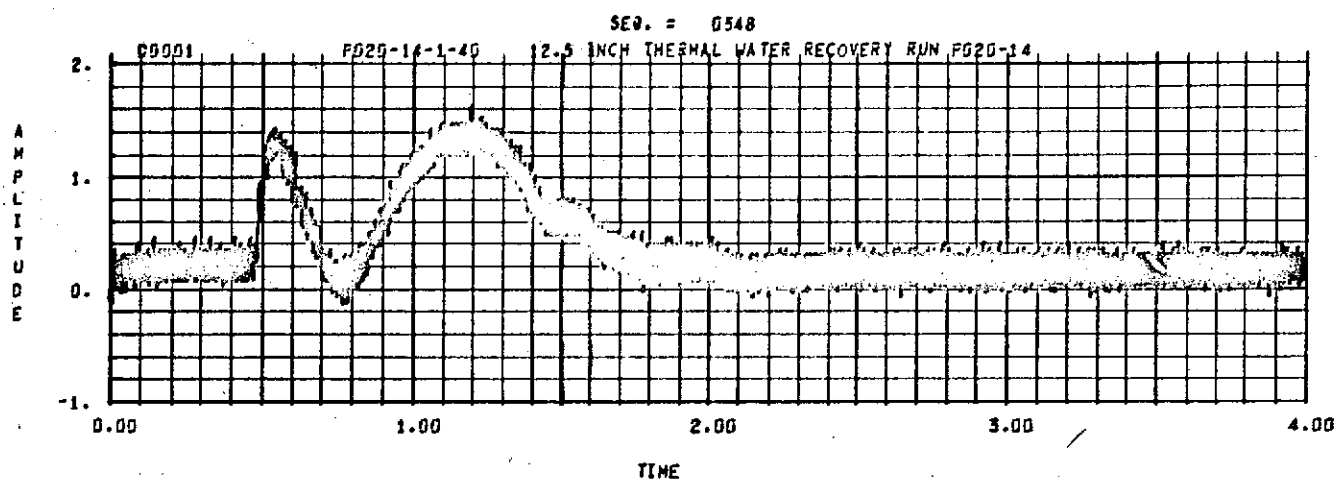
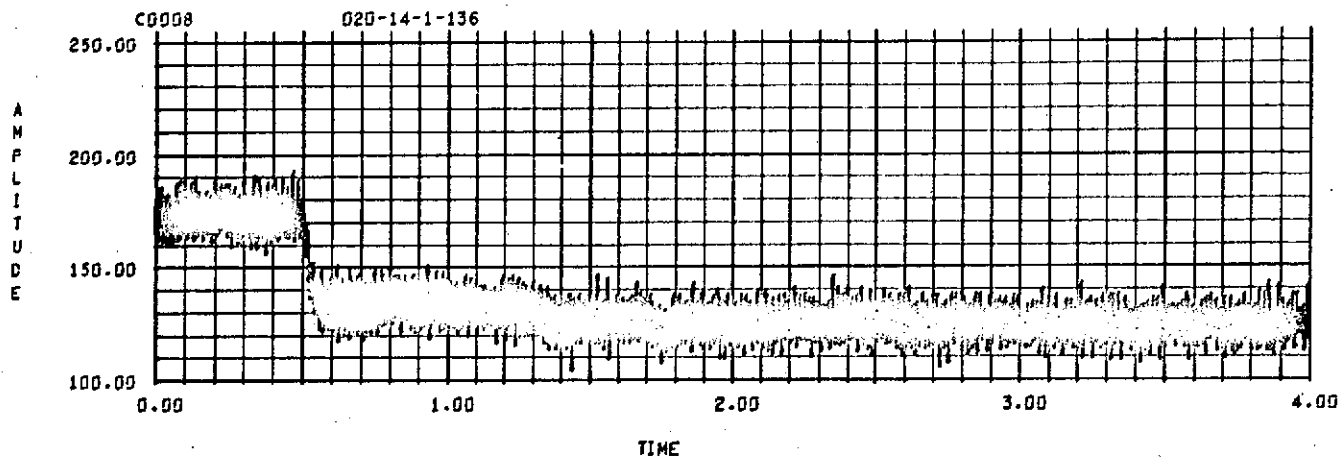




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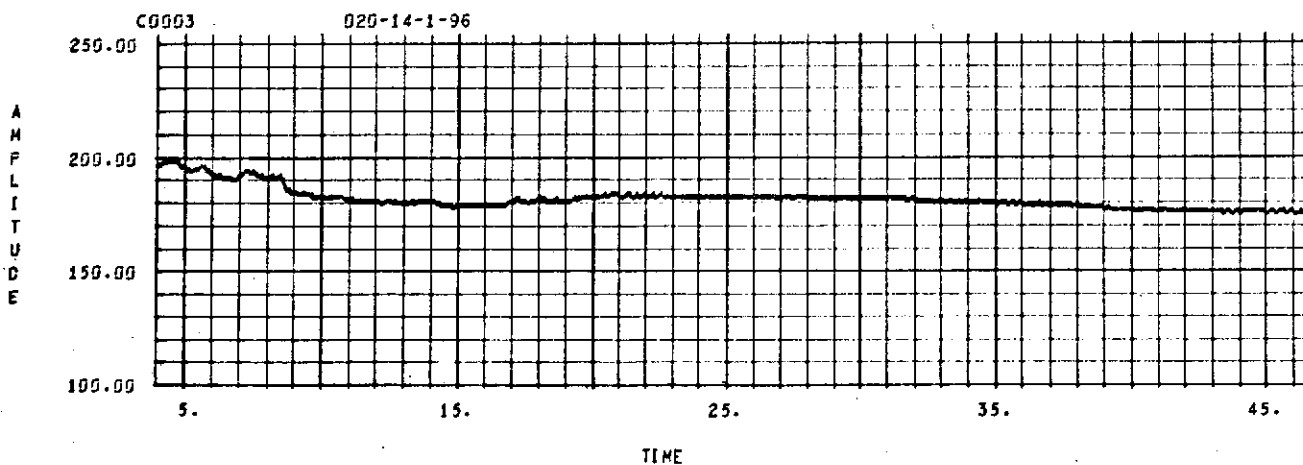
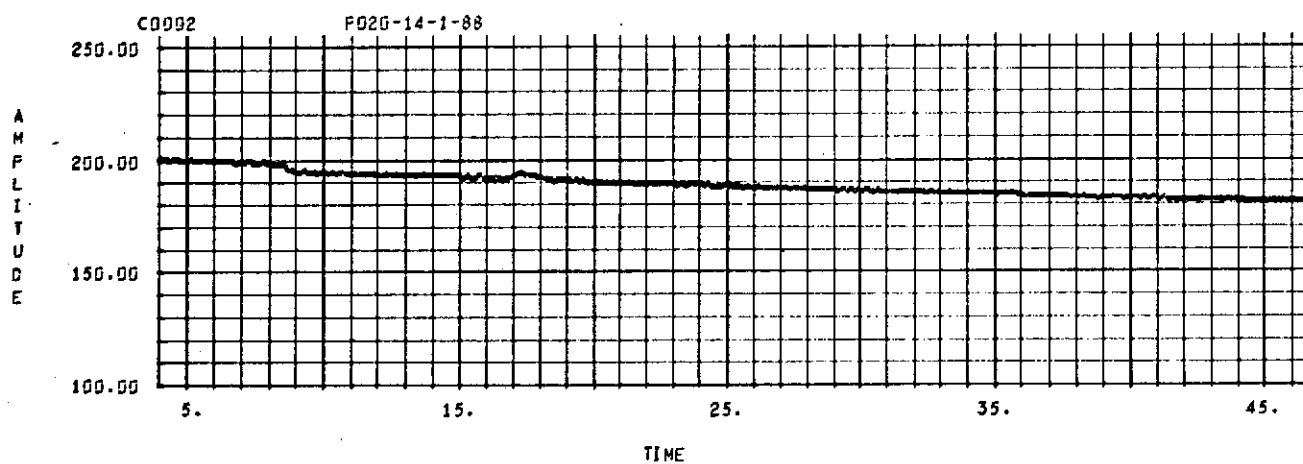
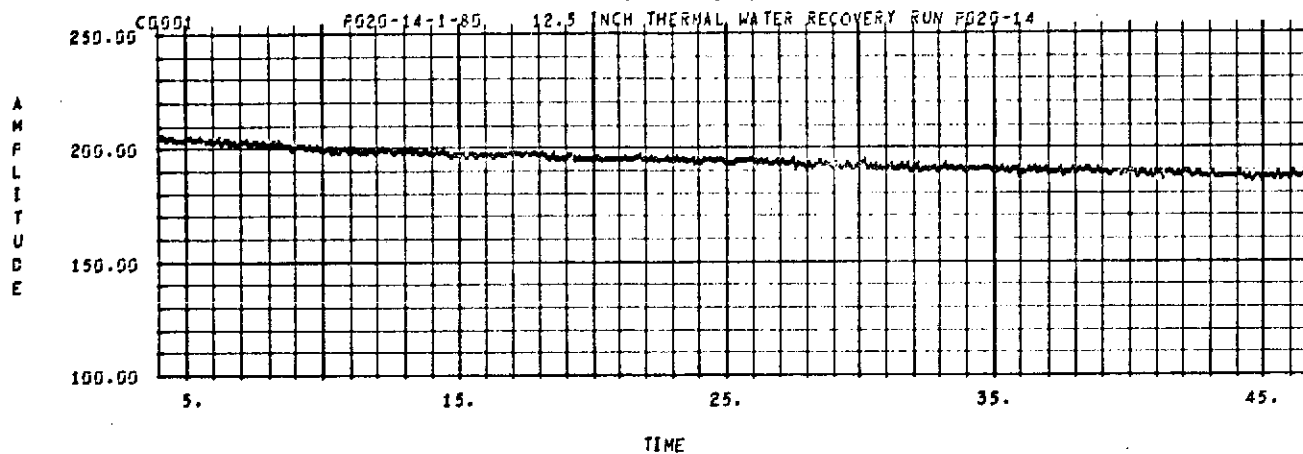
4

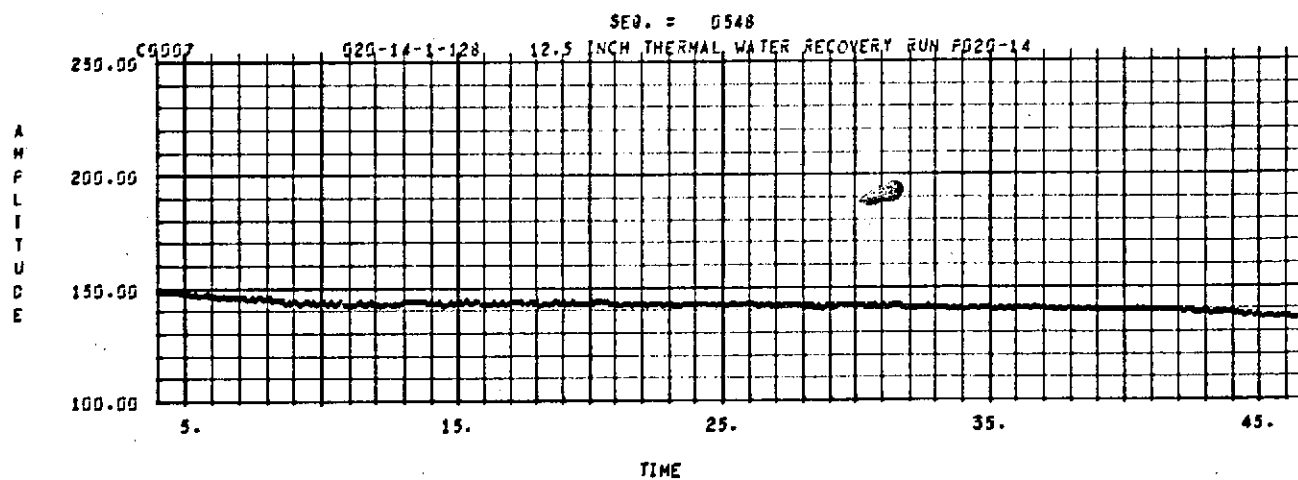
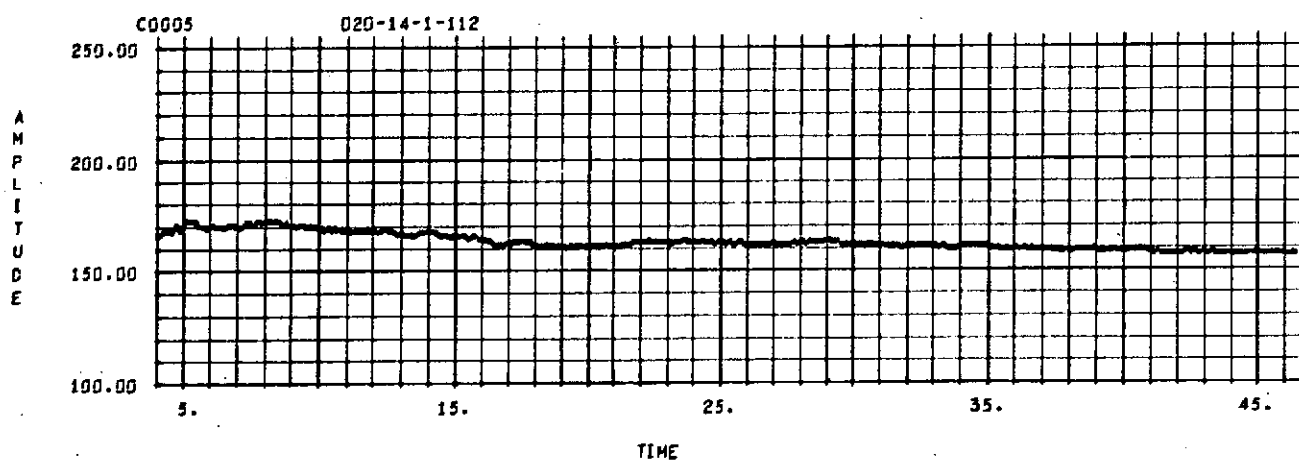
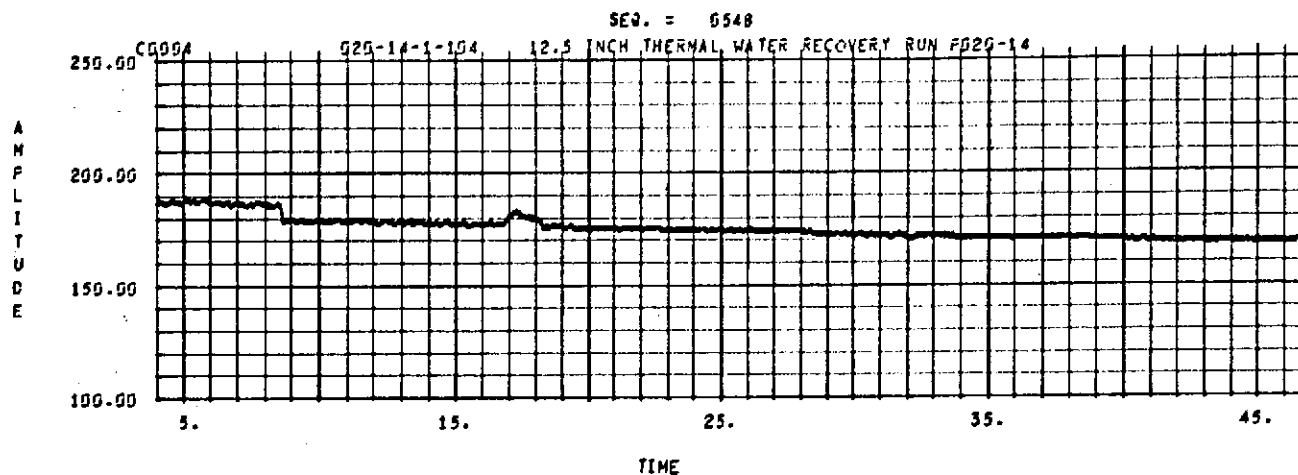


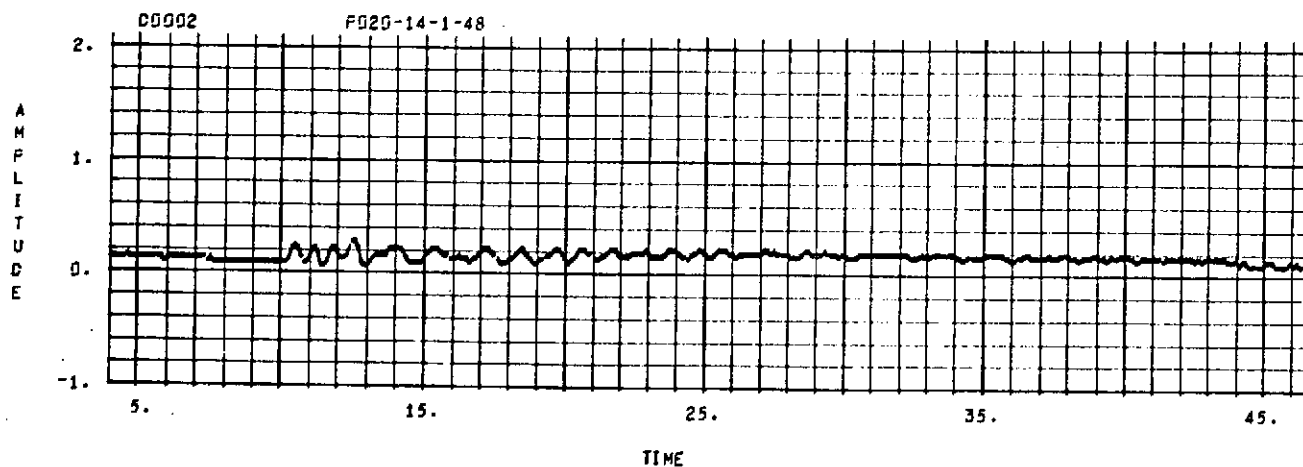
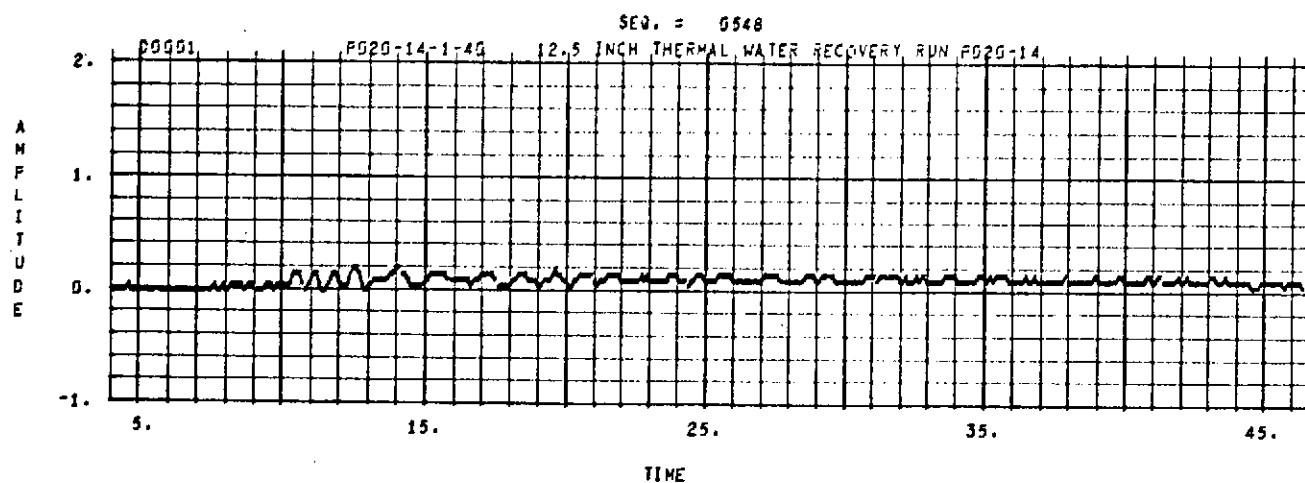
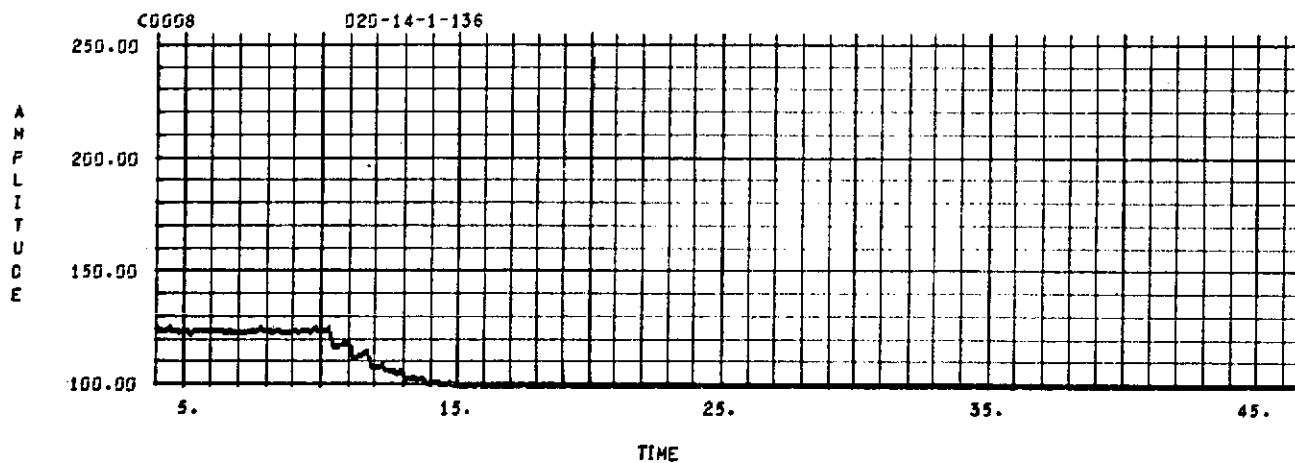


SEQ. = 0548

11

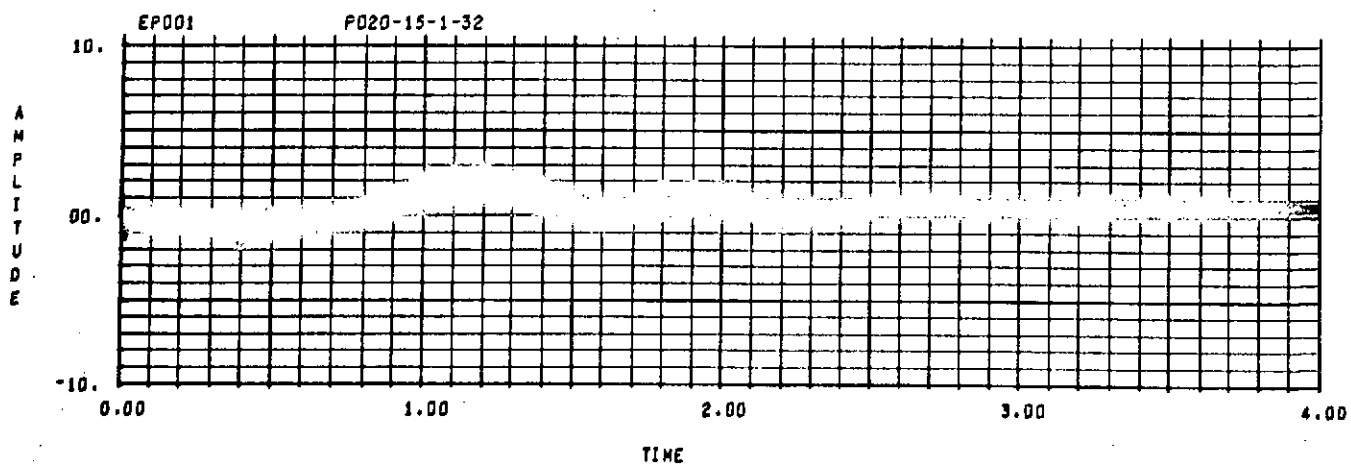
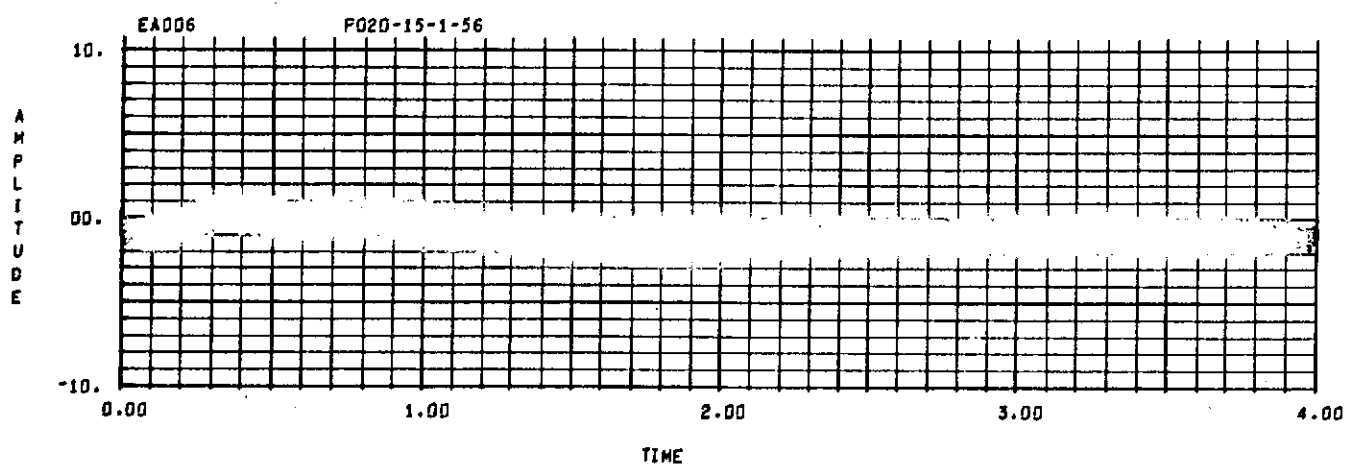
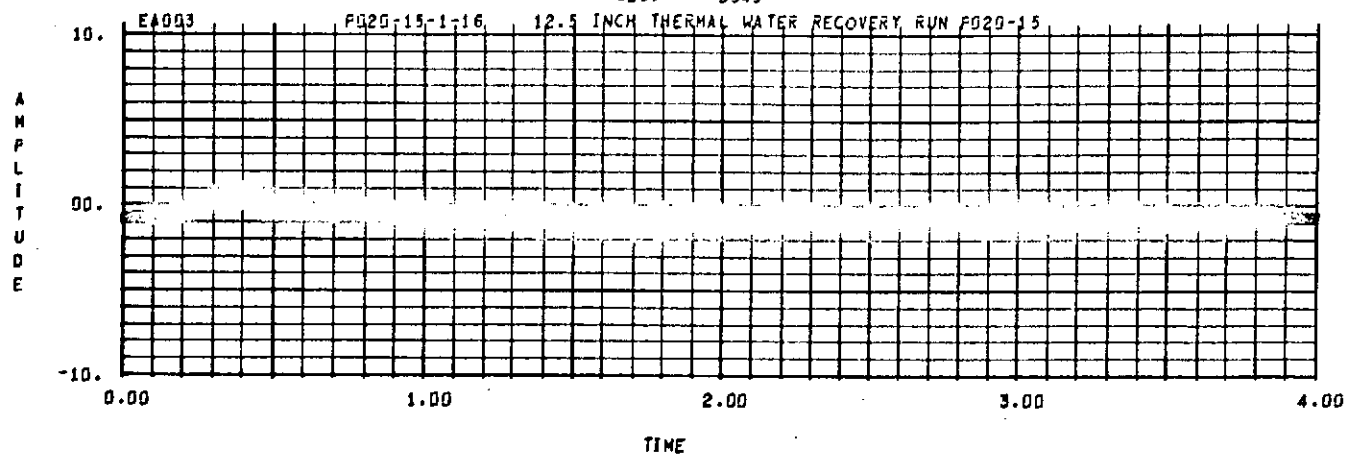






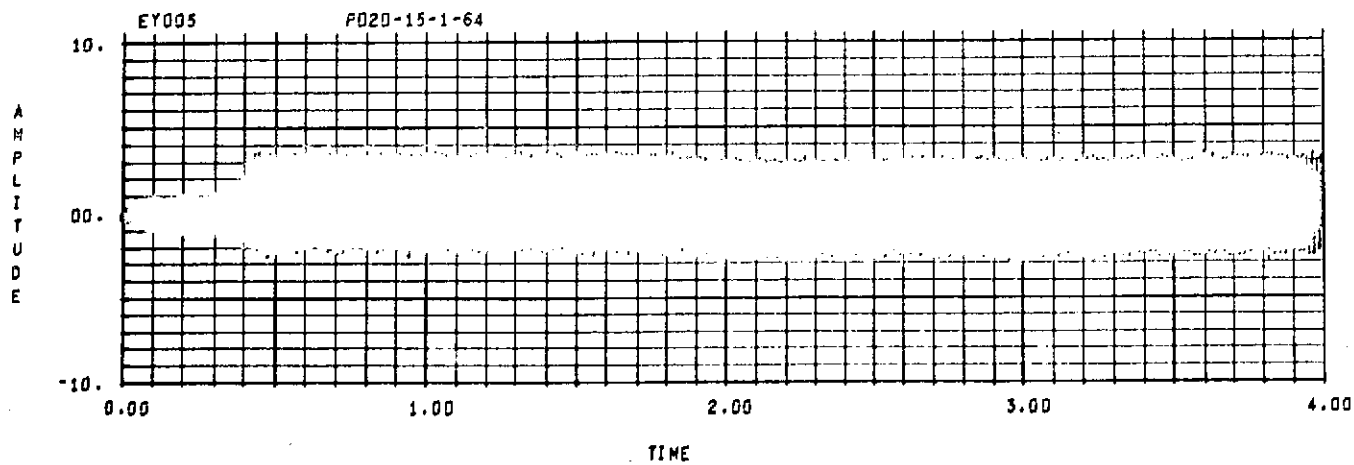
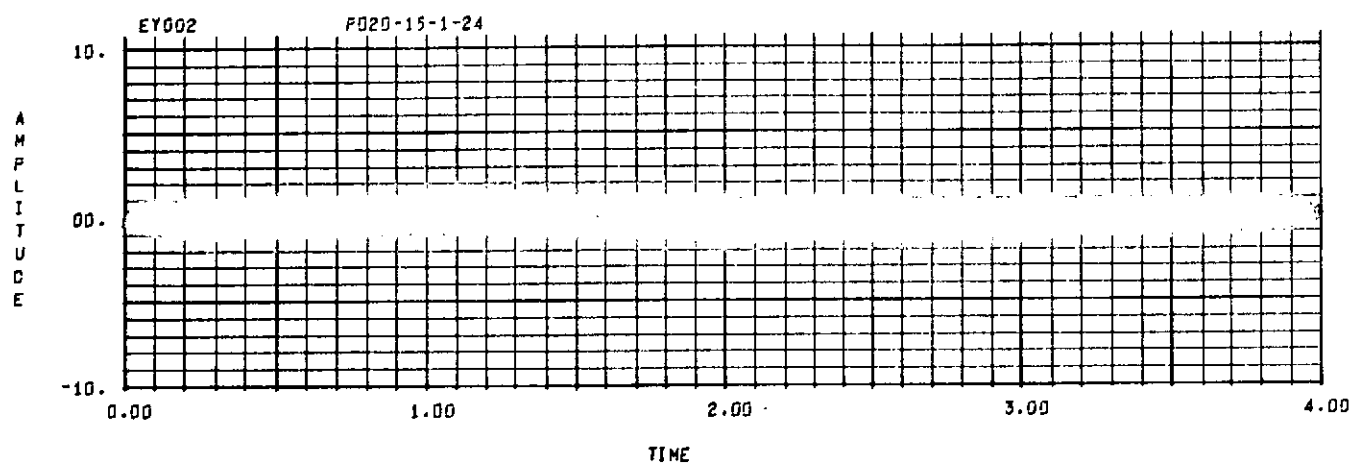
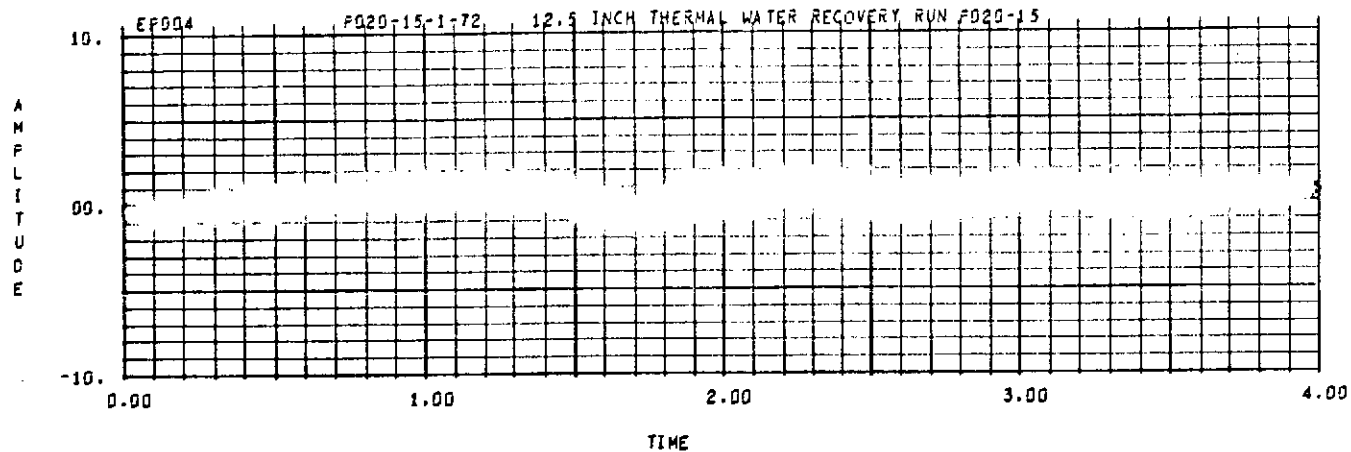
SEQ. = 0549

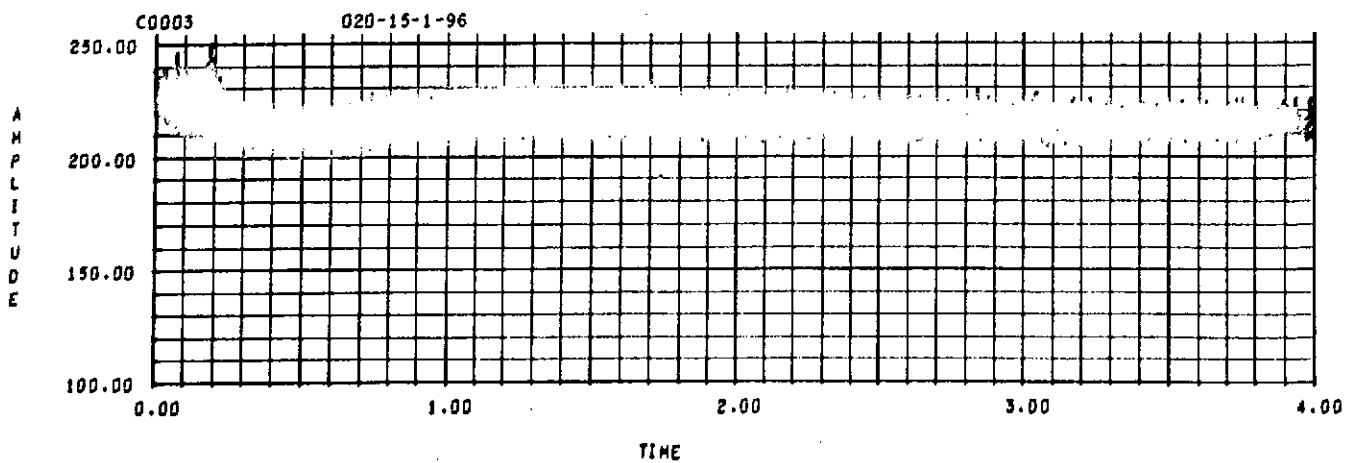
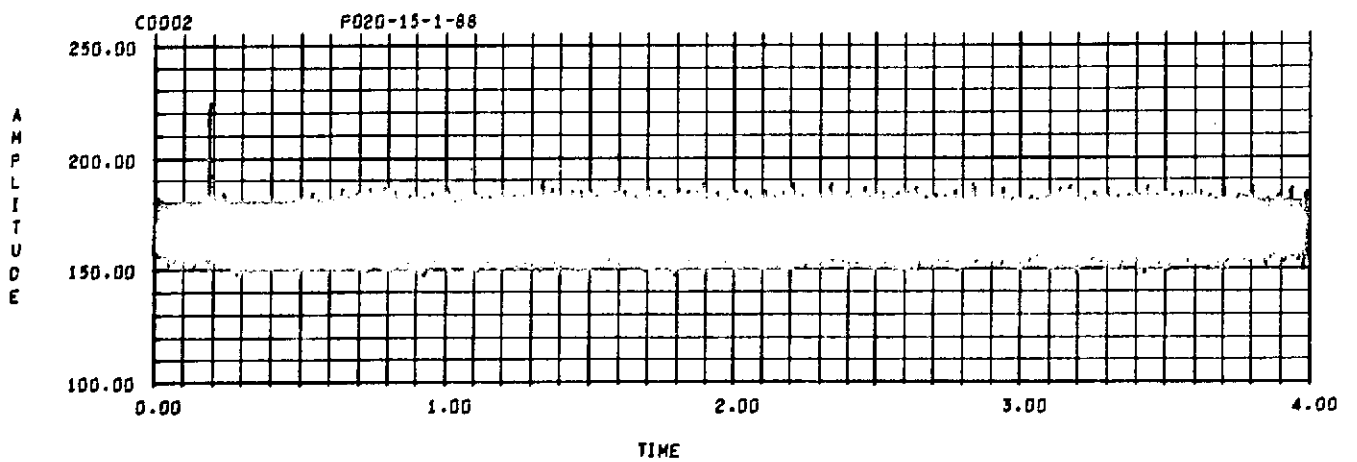
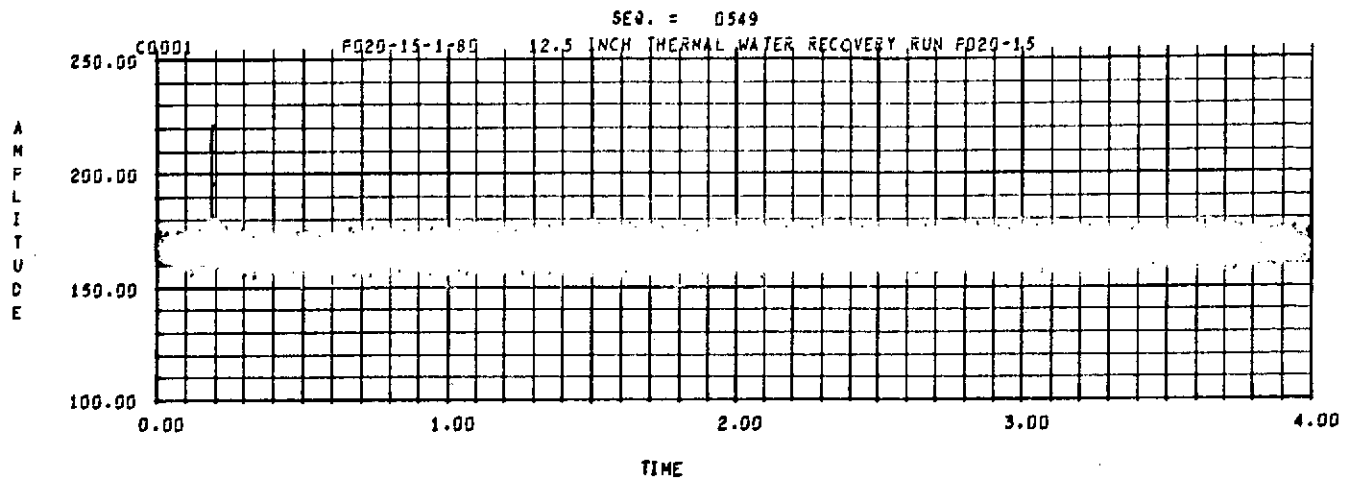
1



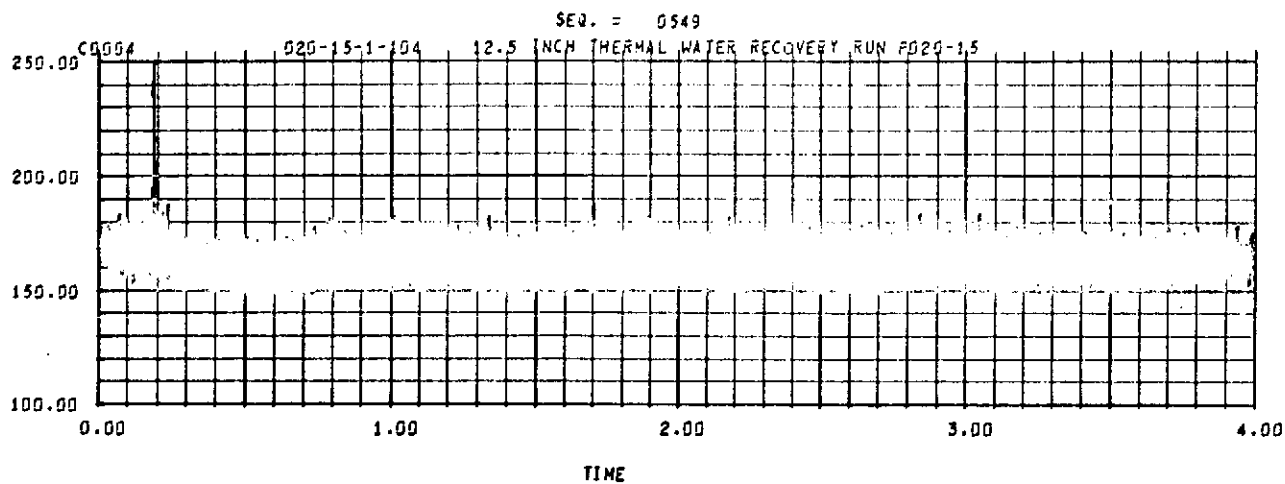
SEQ. = 0549

2

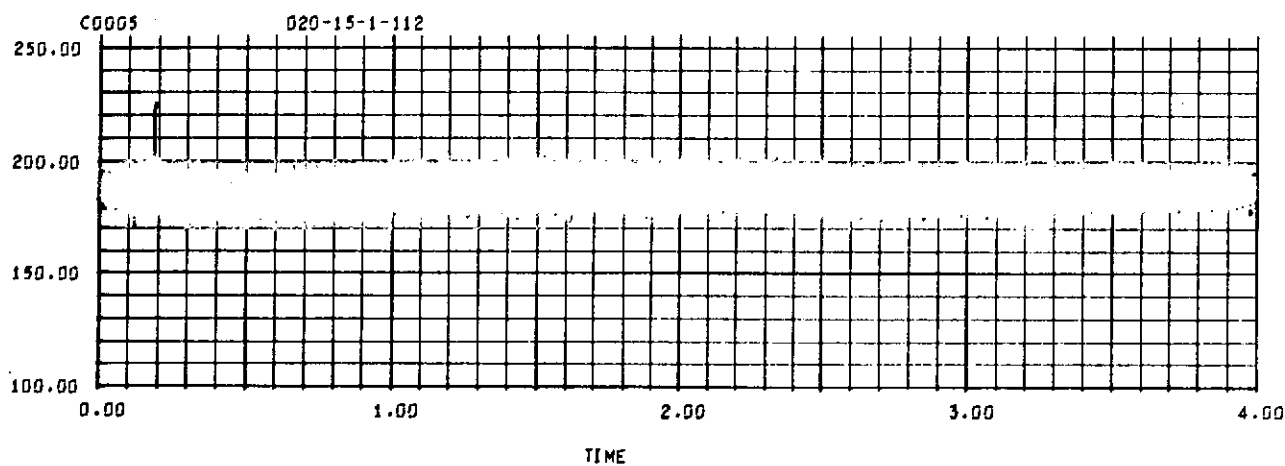




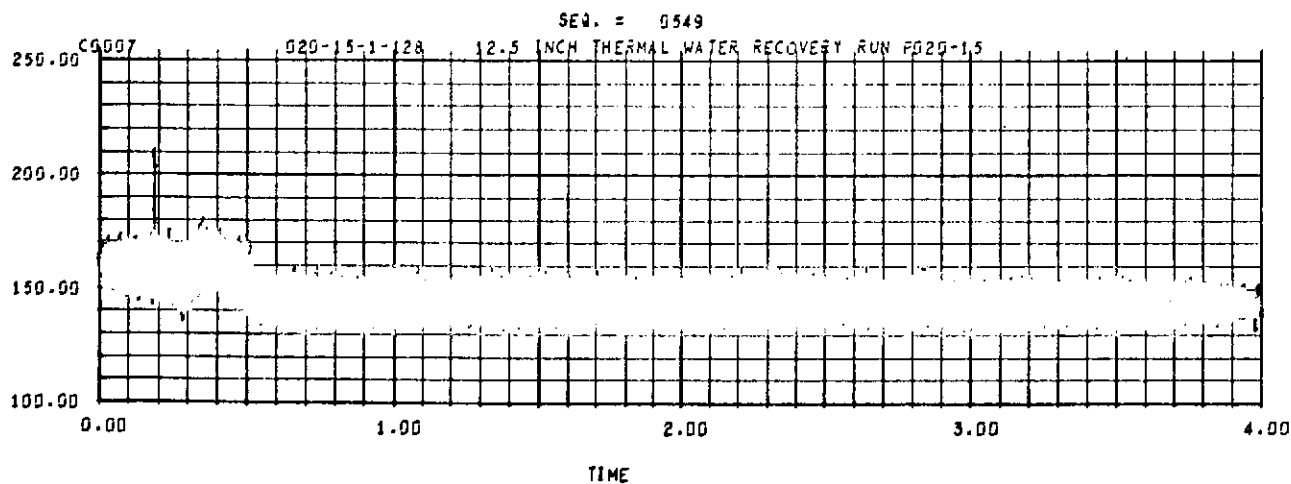
AMPLITUDE

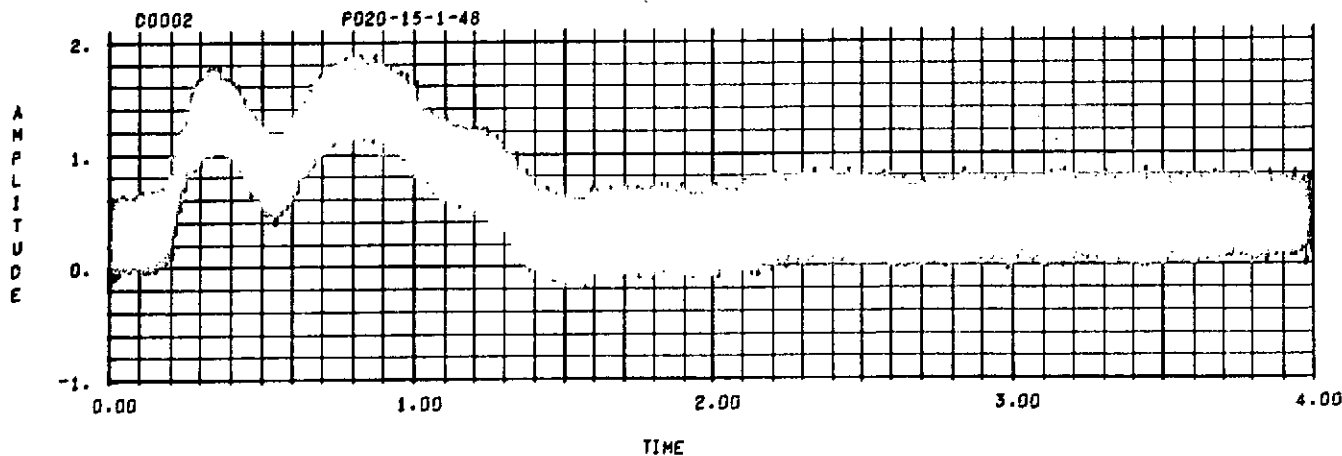
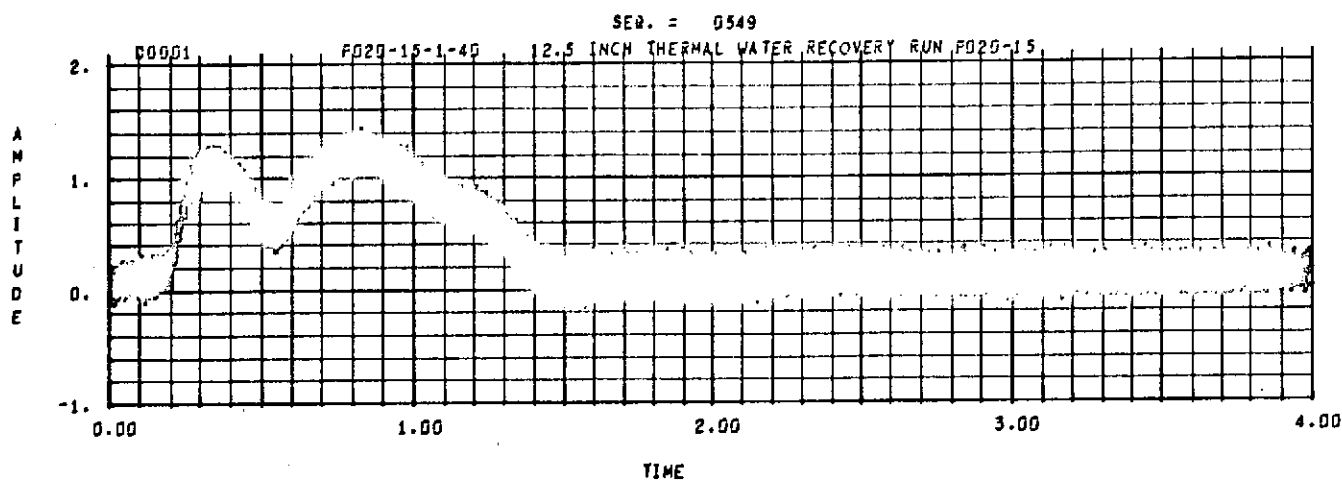
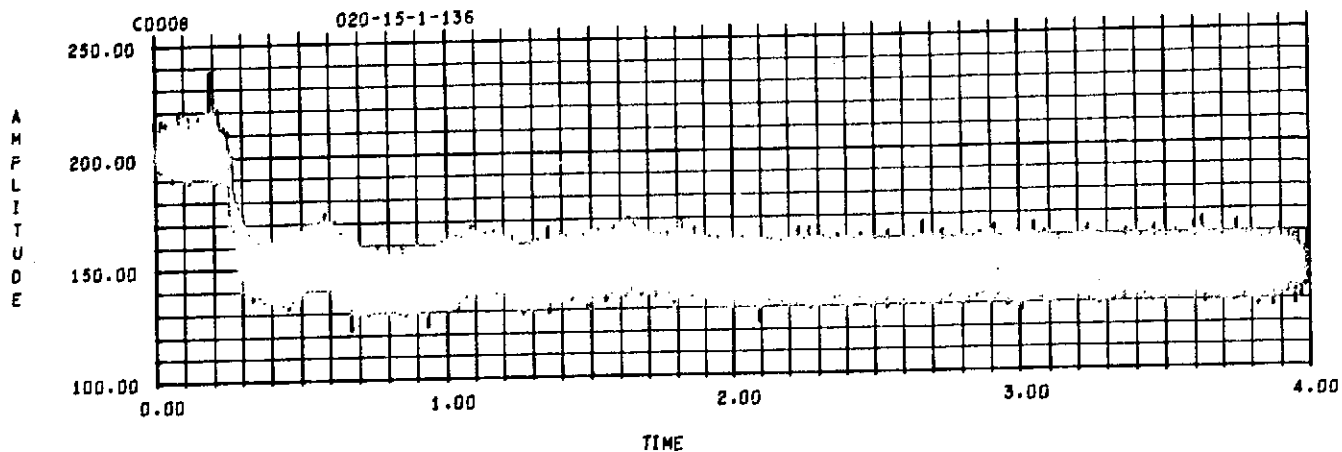


AMPLITUDE



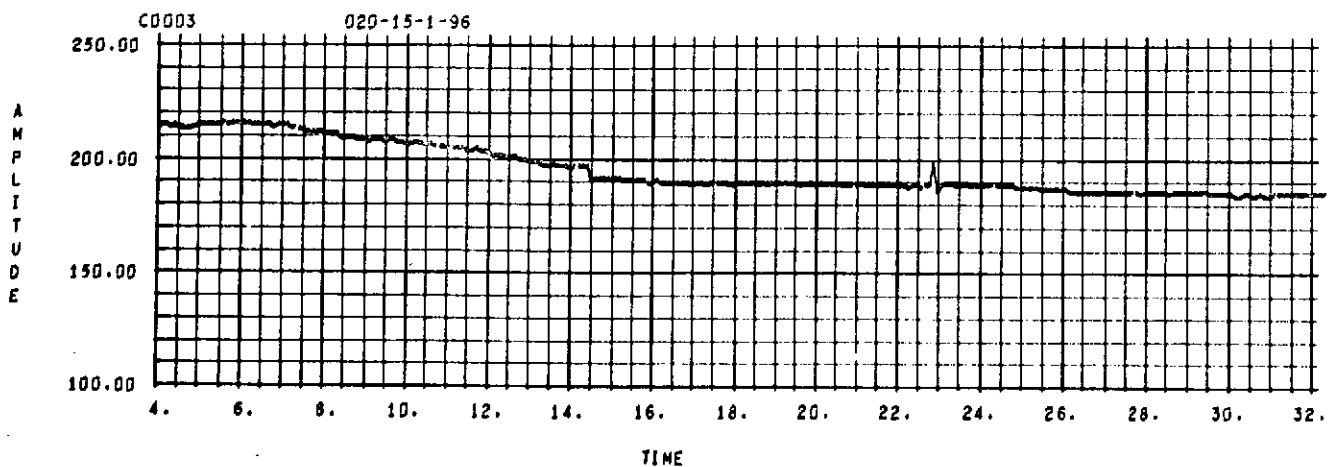
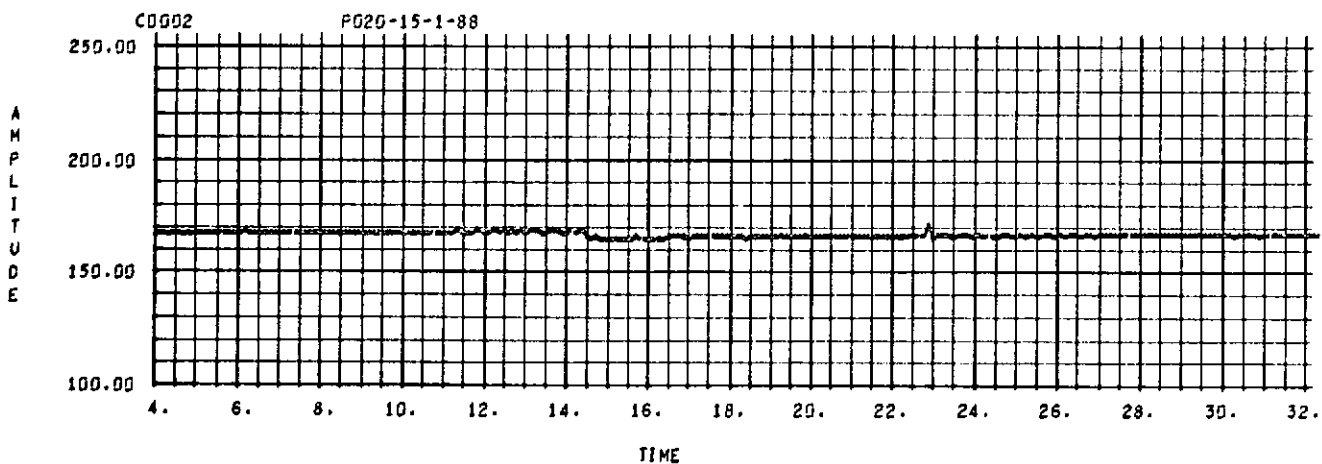
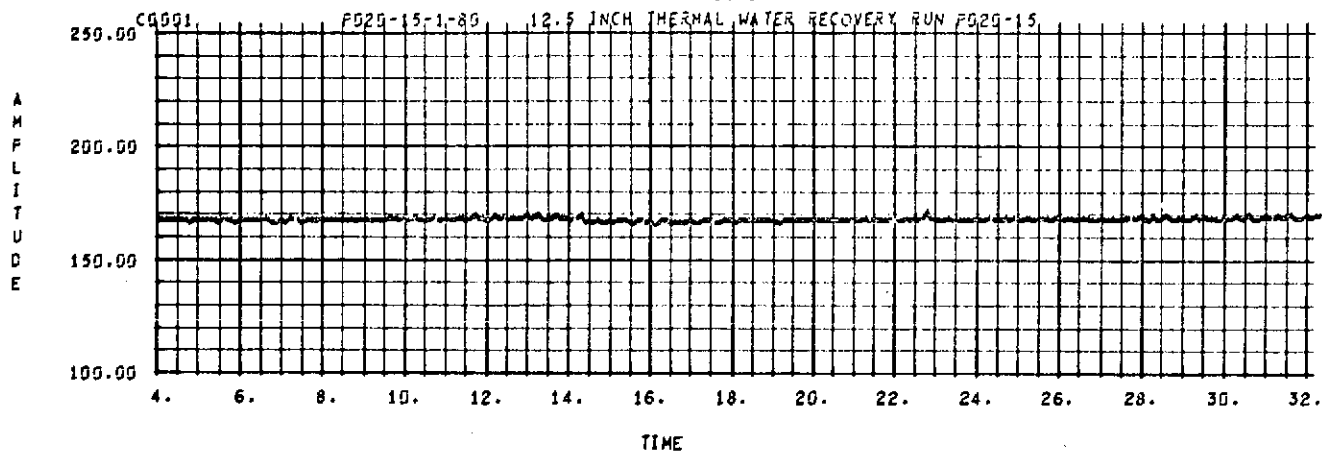
AMPLITUDE

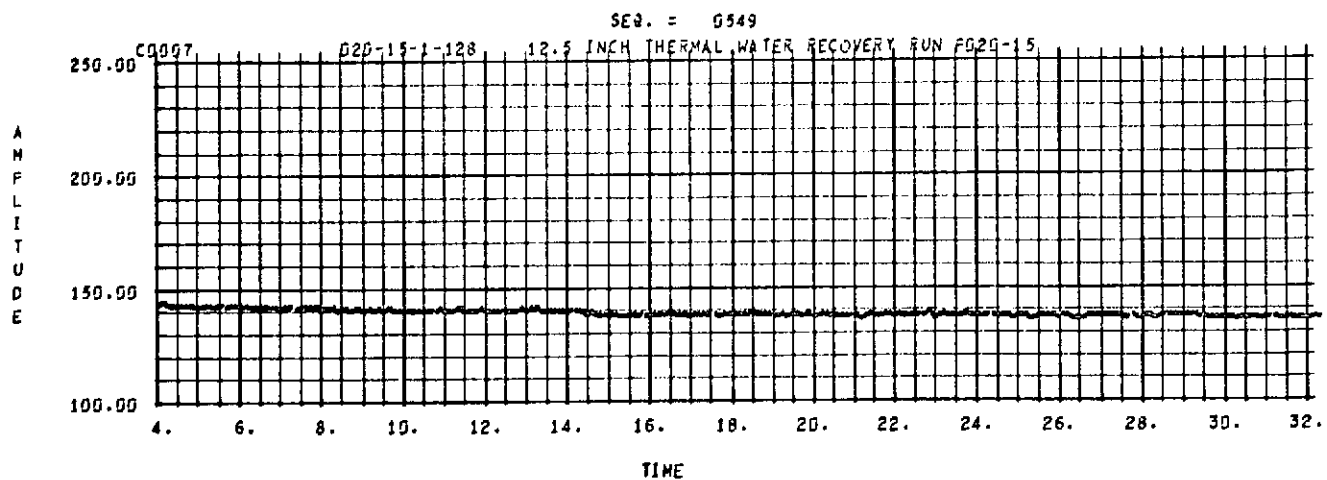
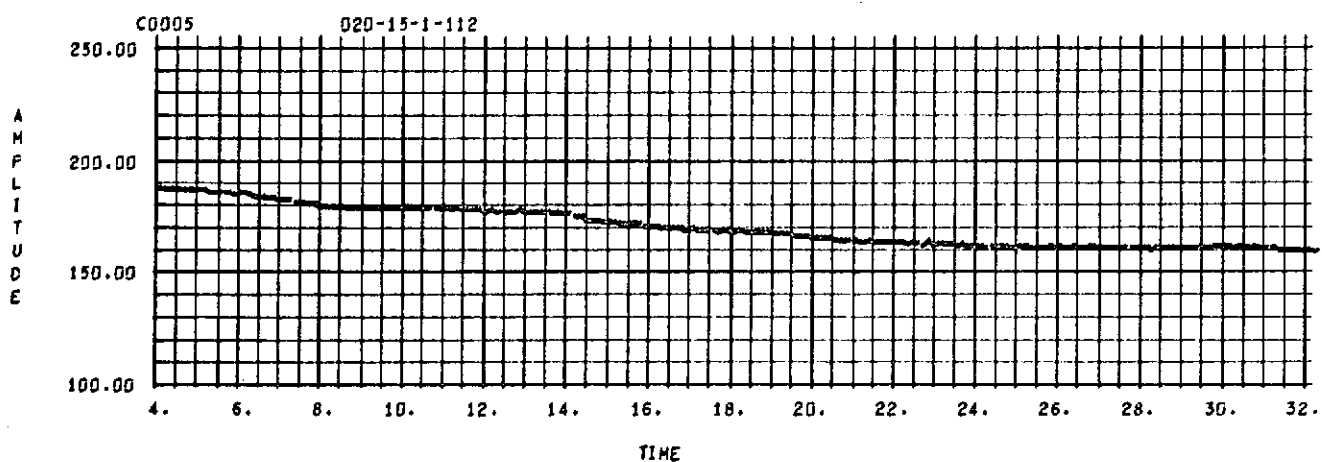
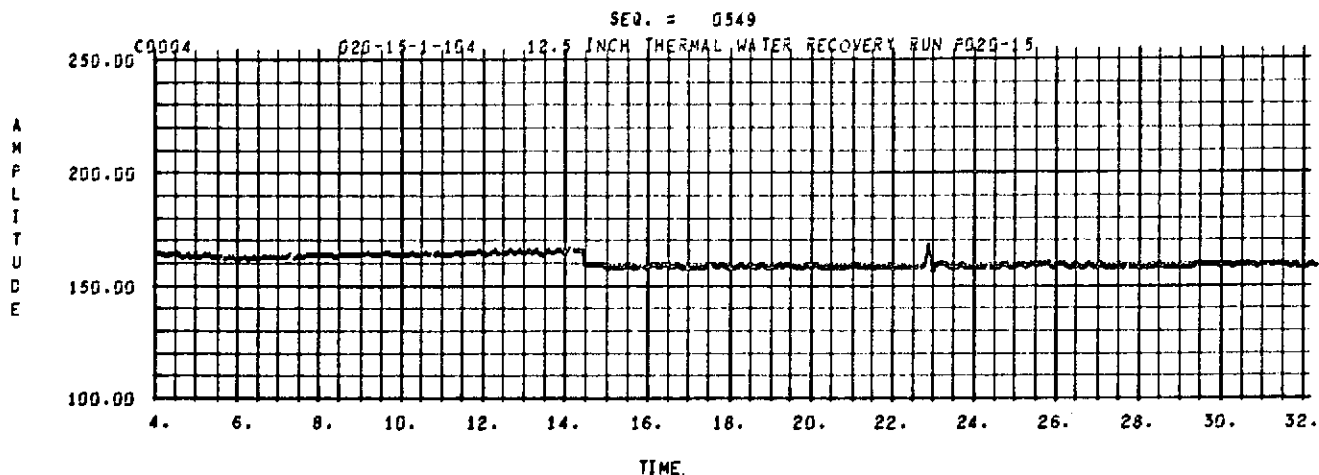


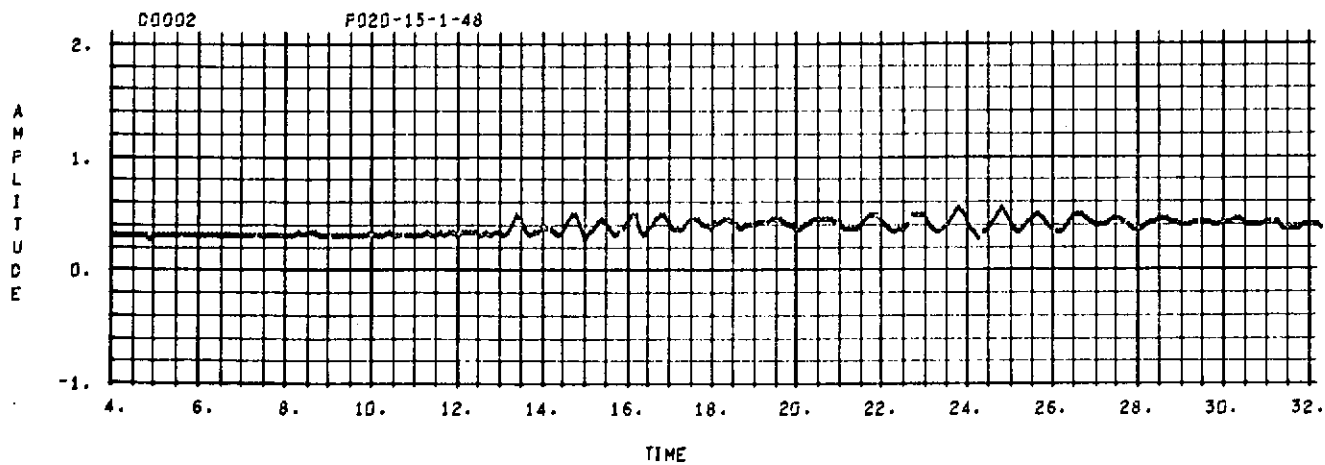
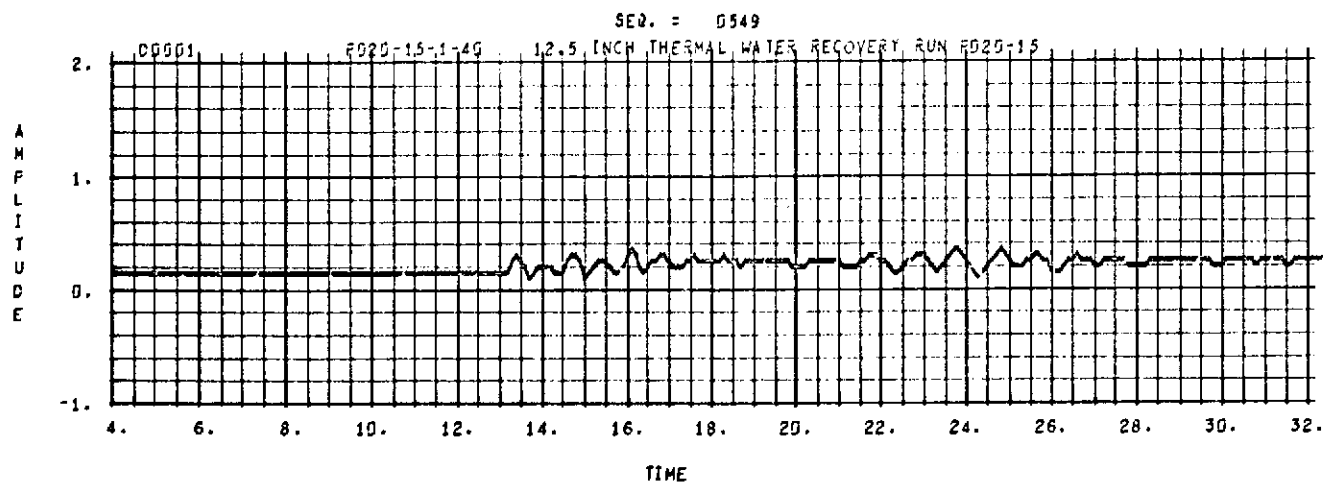
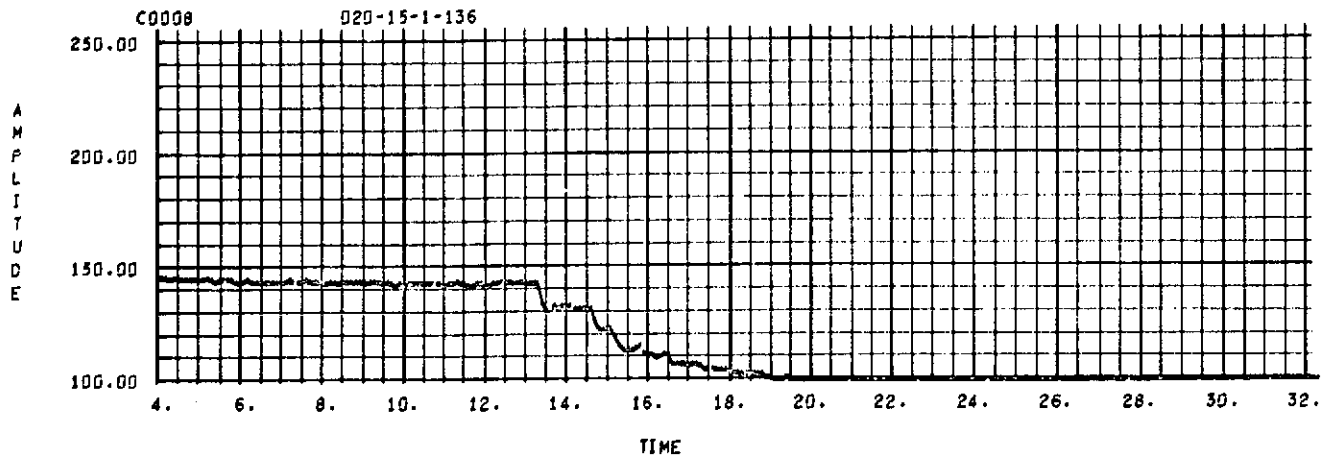


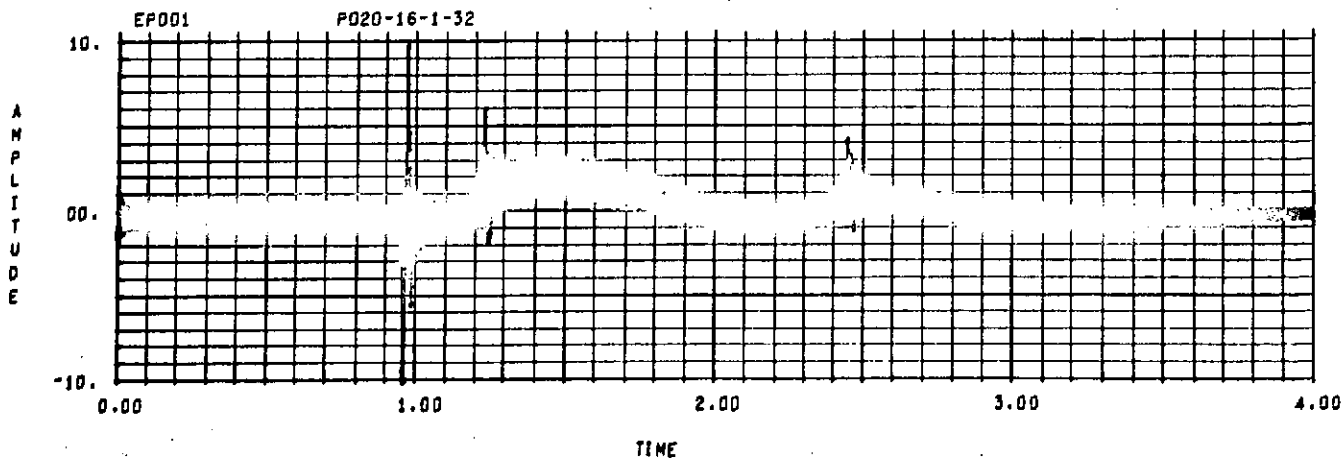
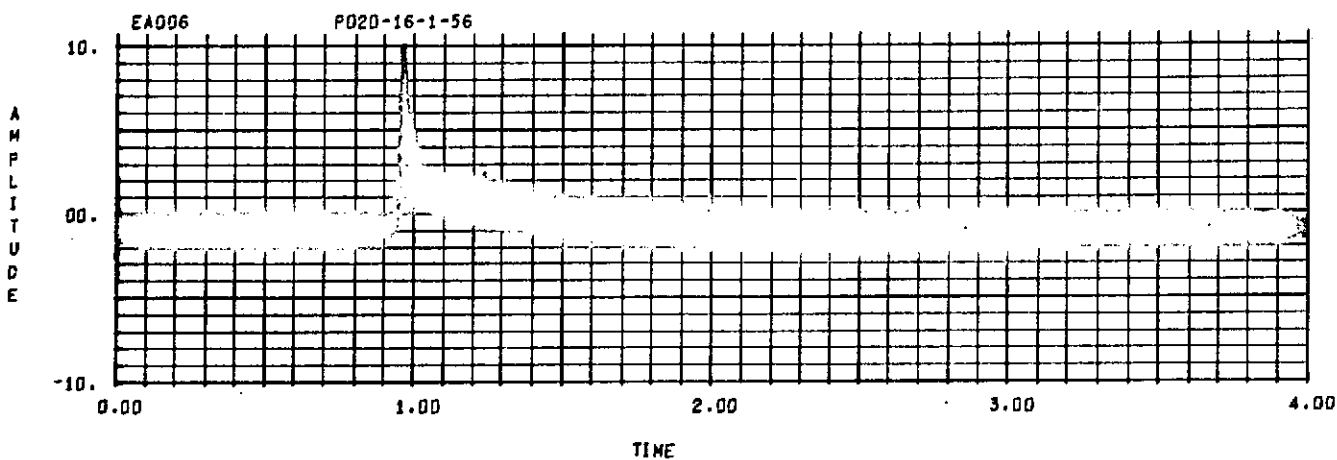
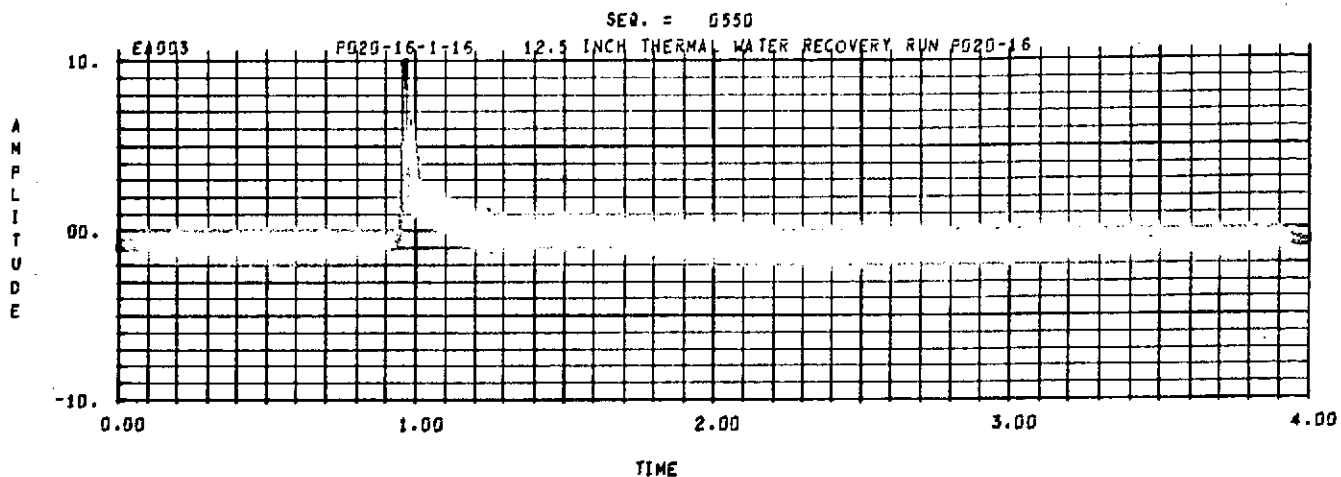
SEQ. = 0549

11

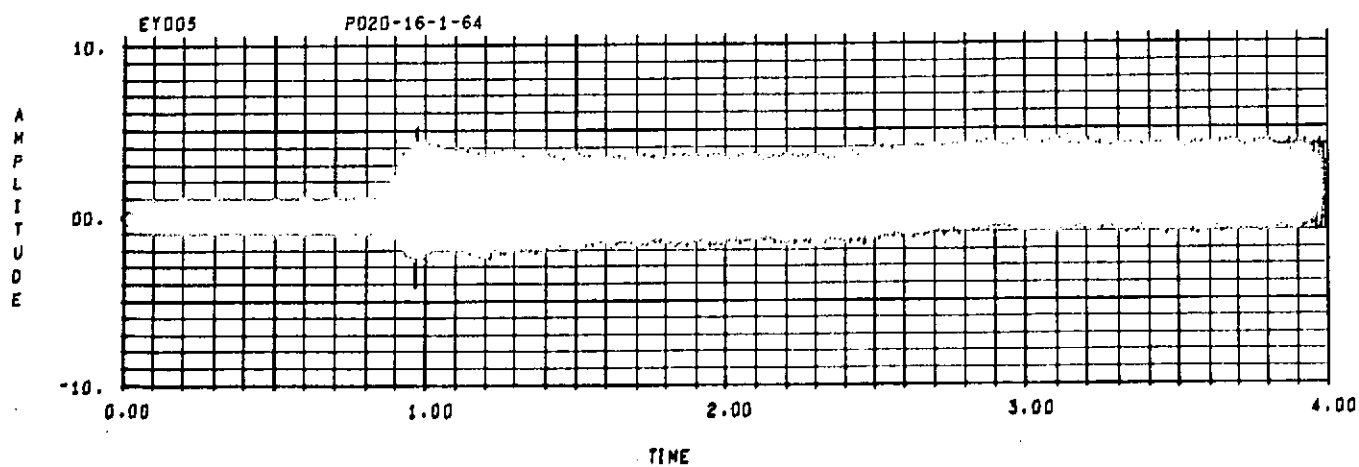
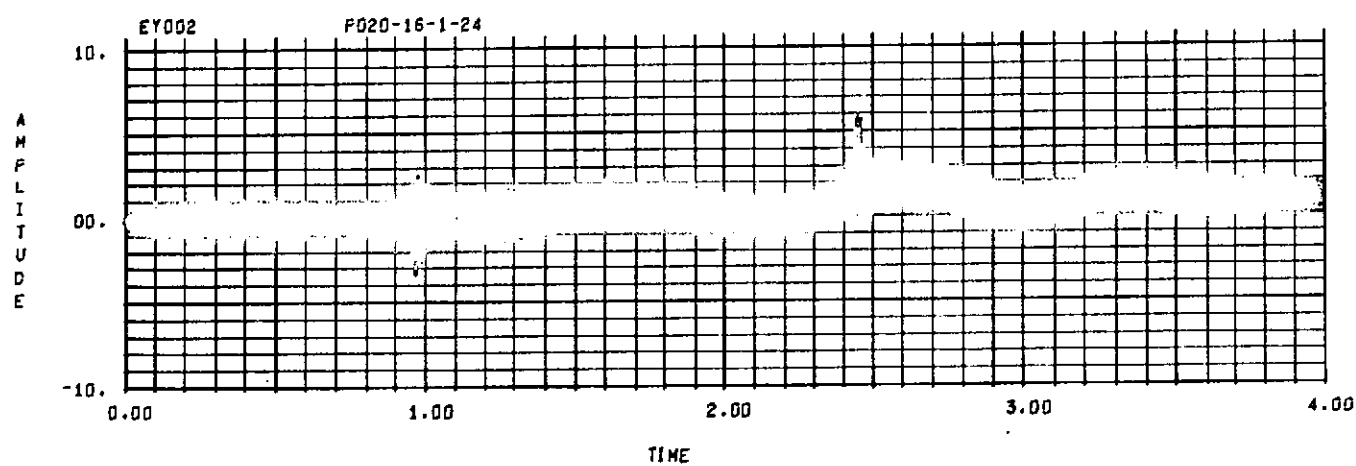
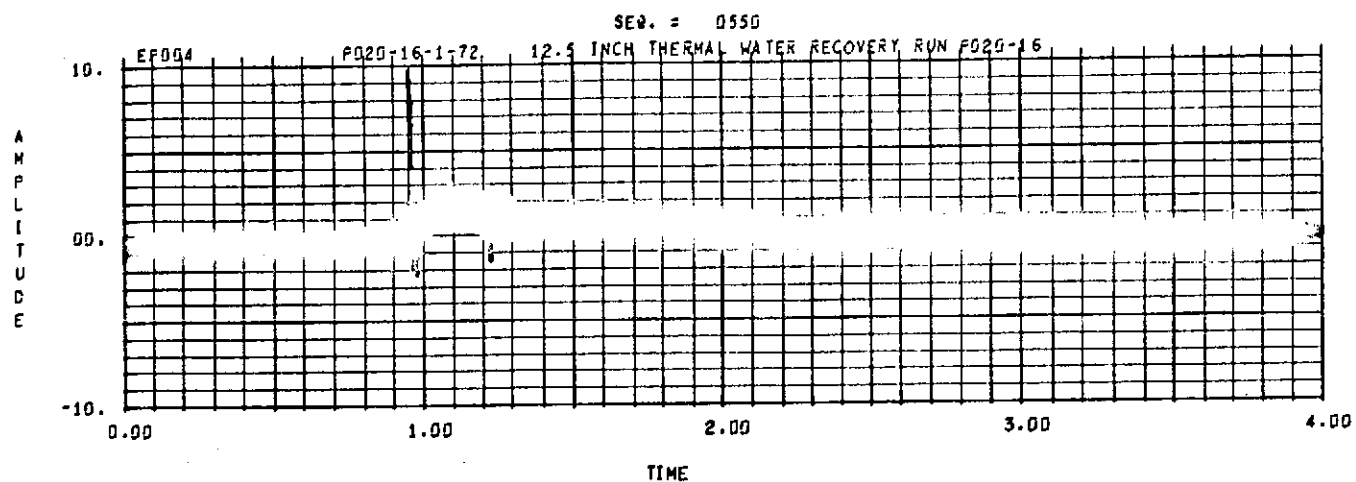


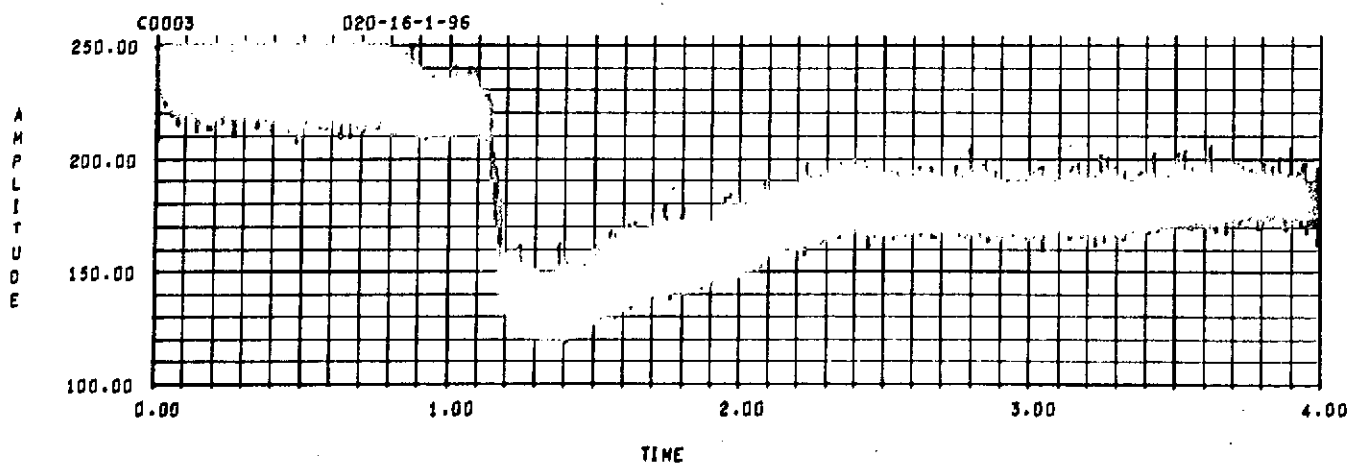
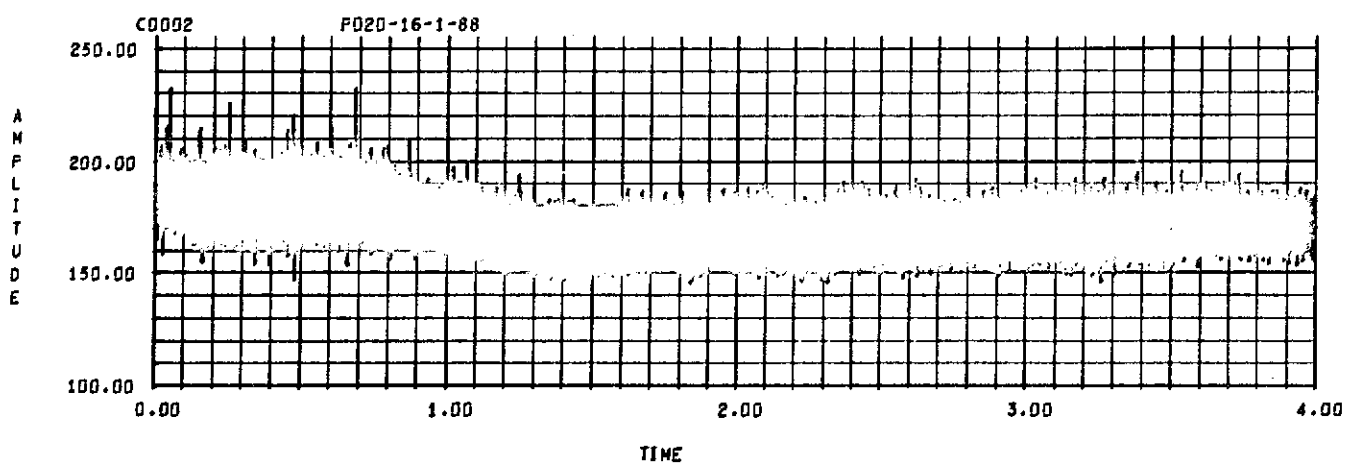
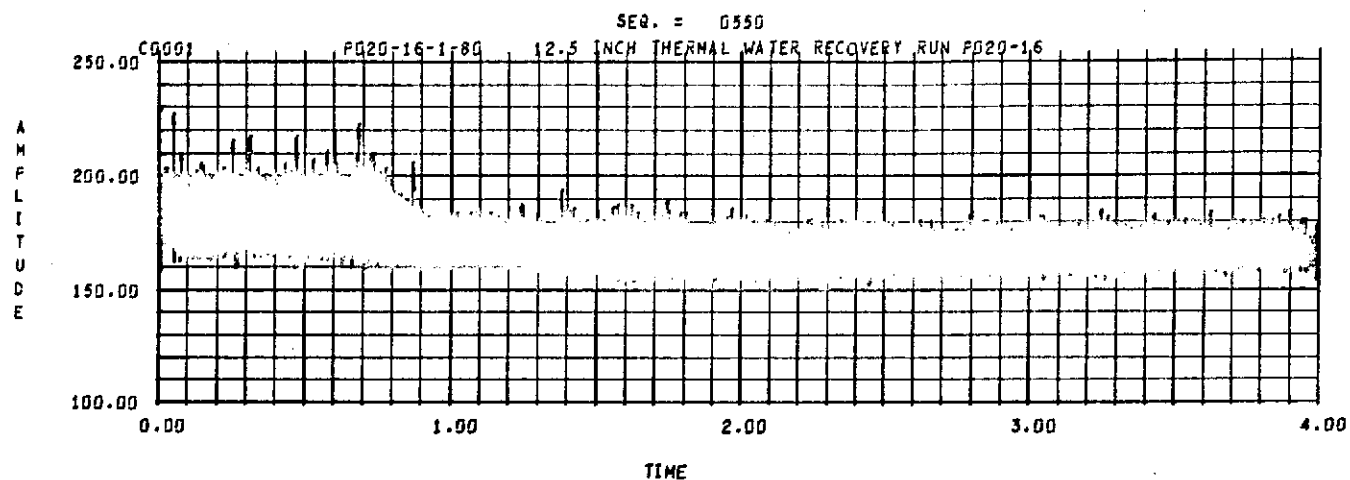






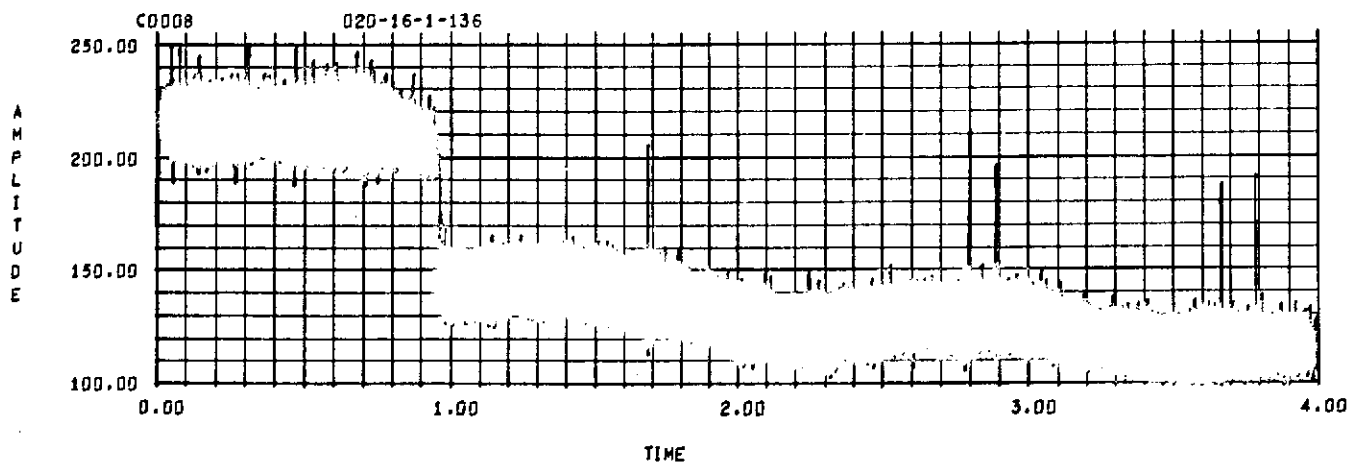
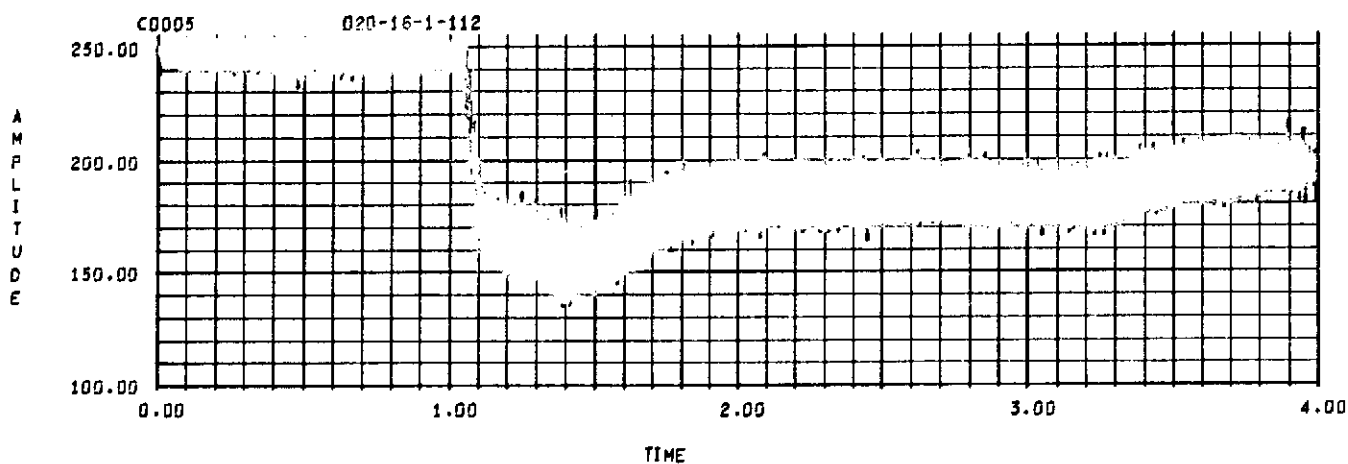
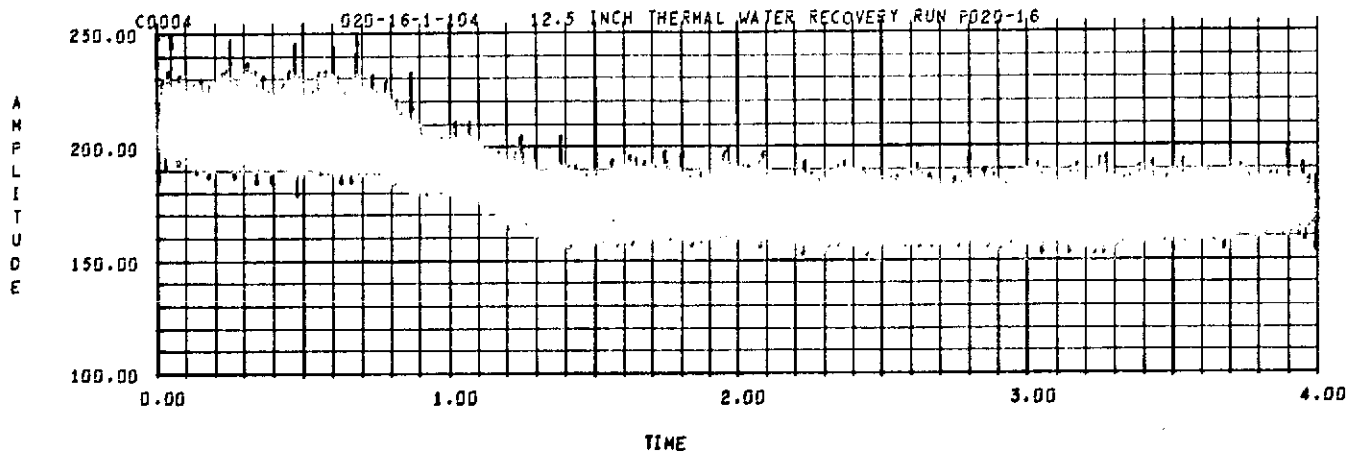
C-2

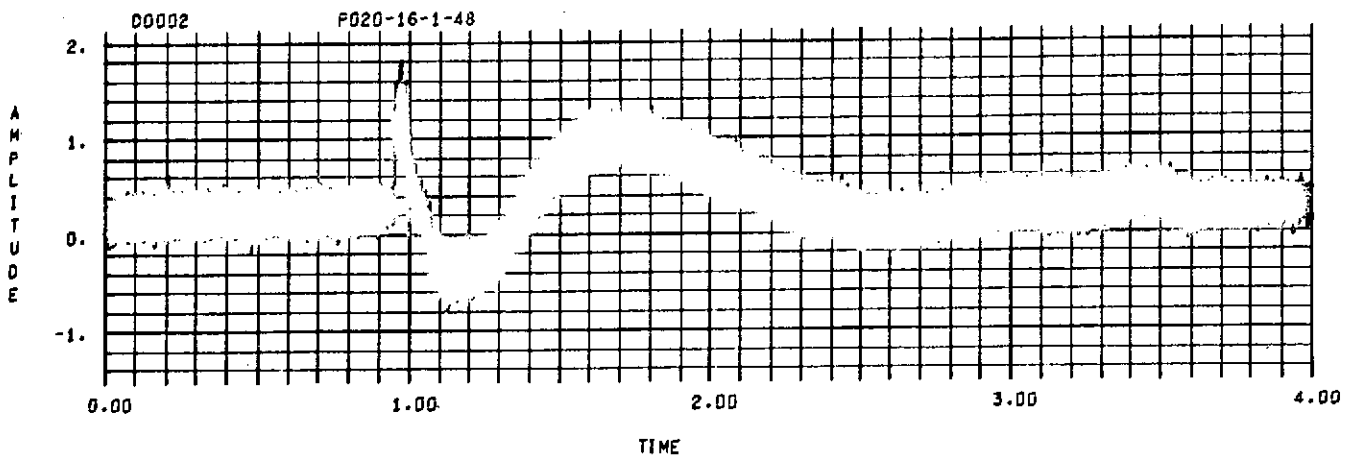
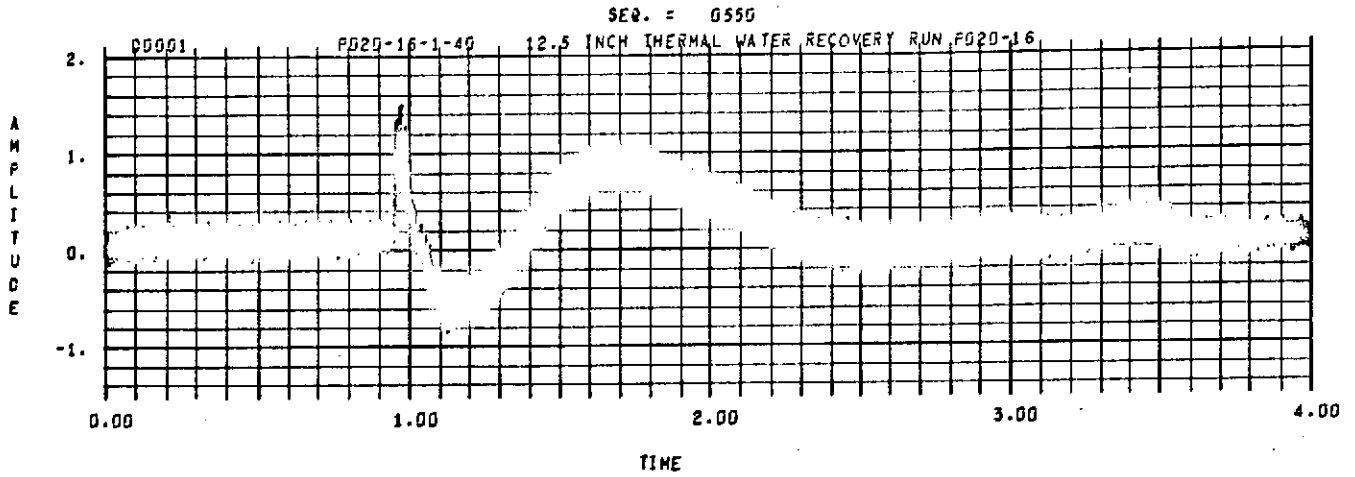


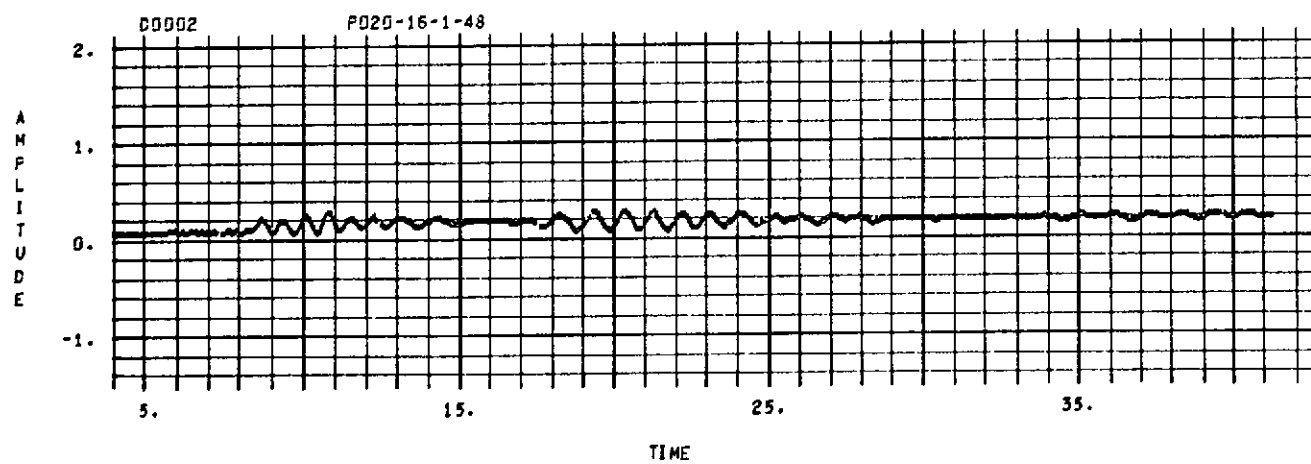
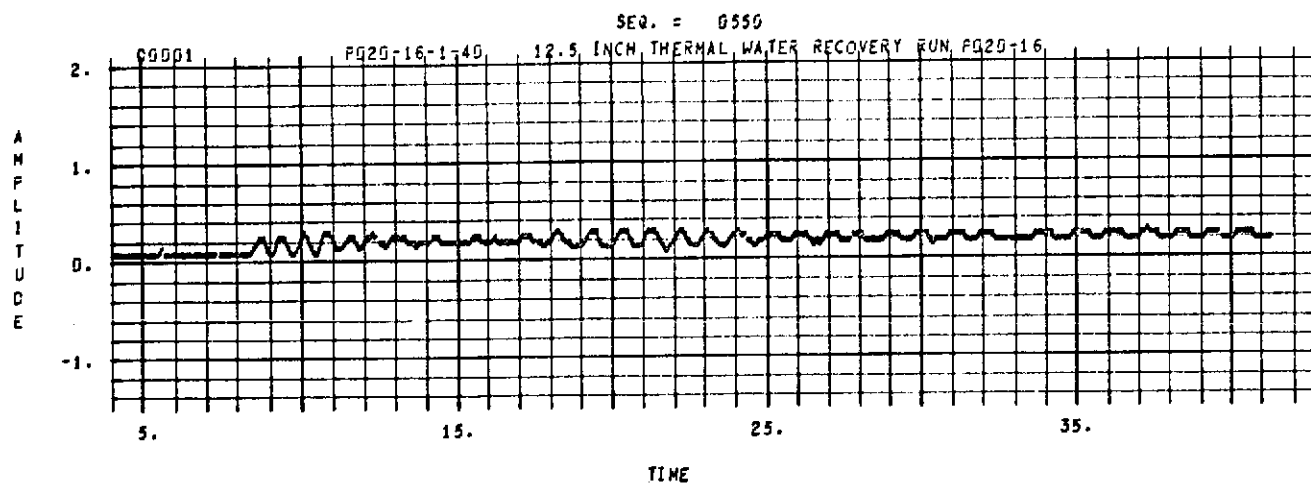


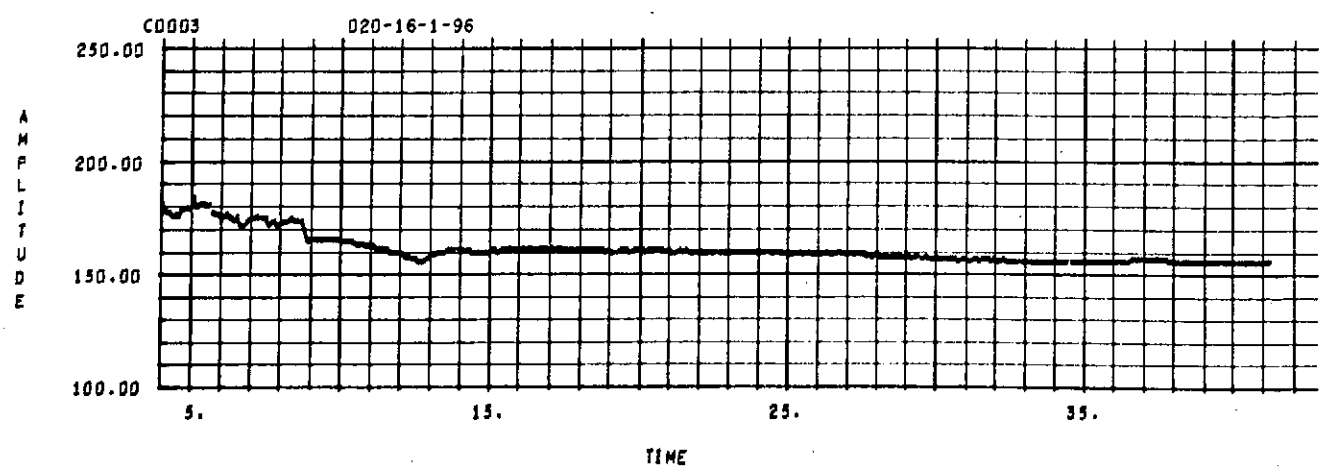
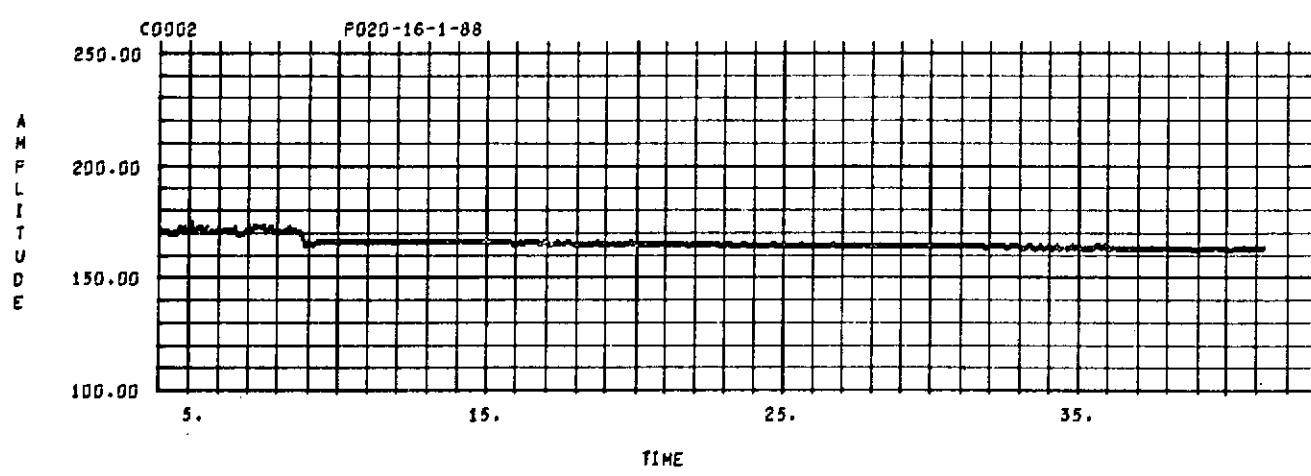
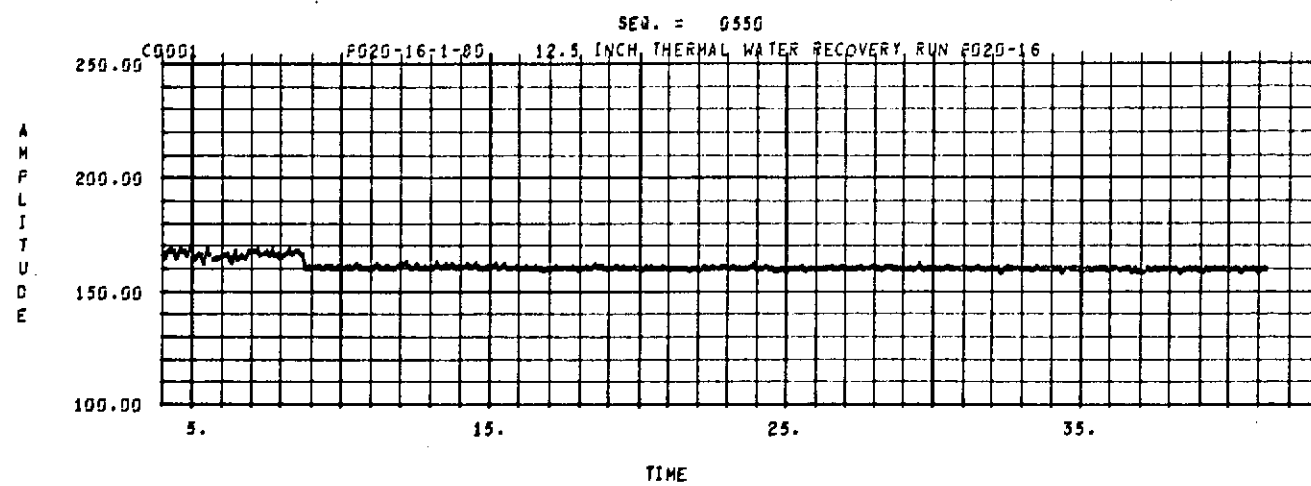
SEQ. = 0550

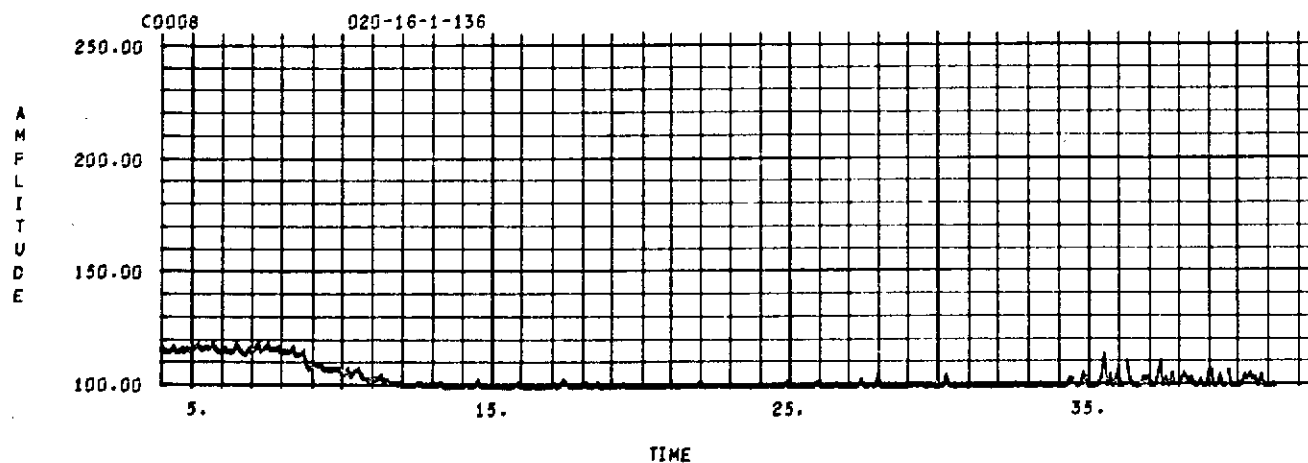
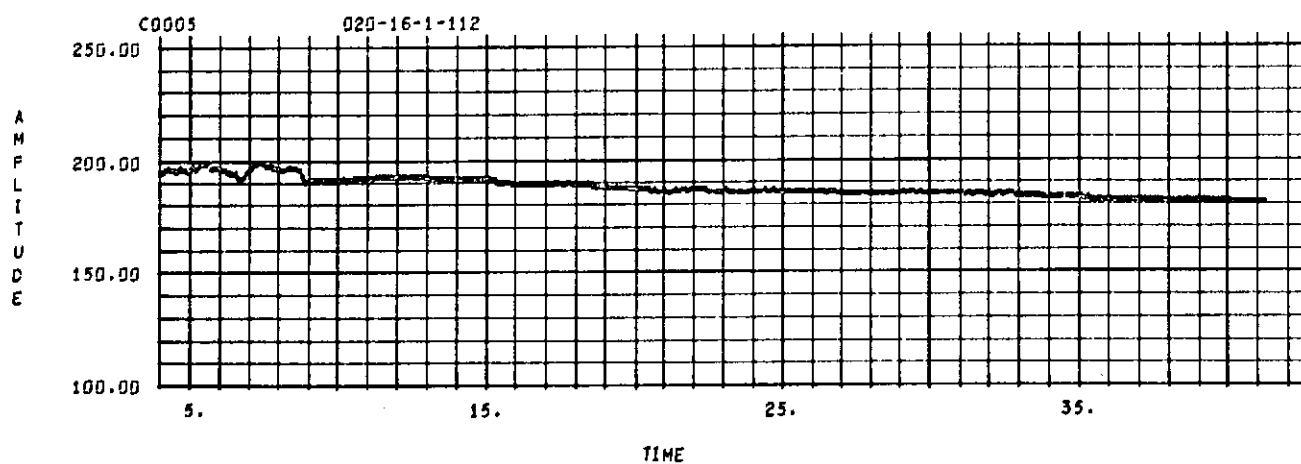
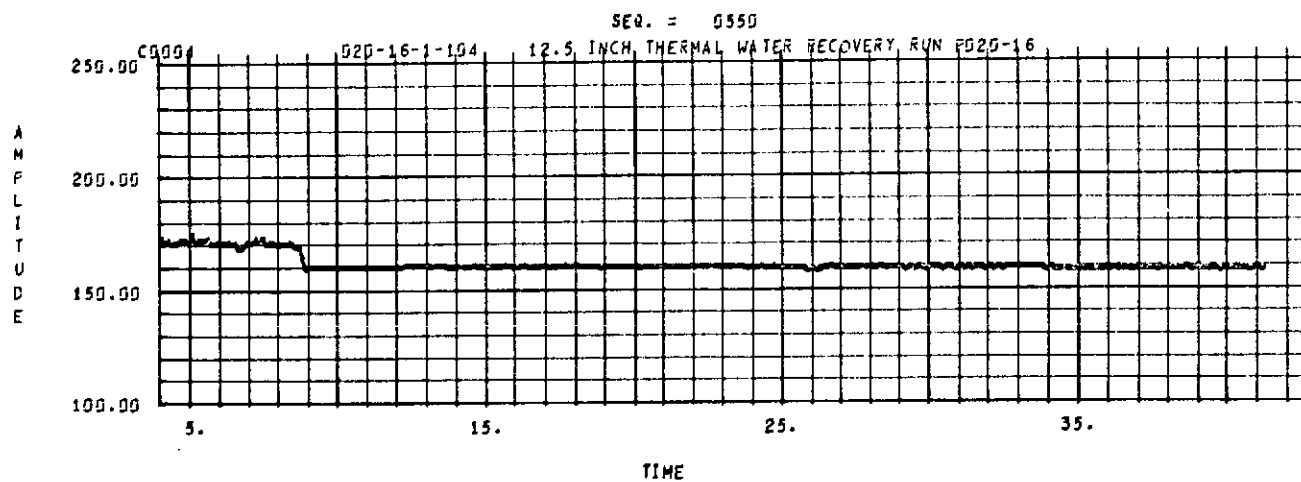
4





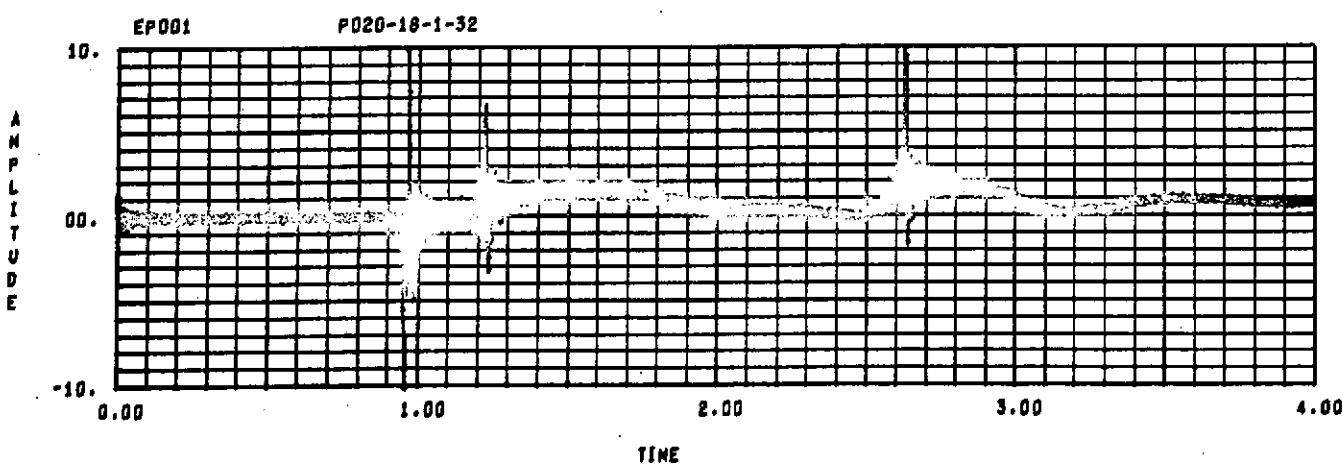
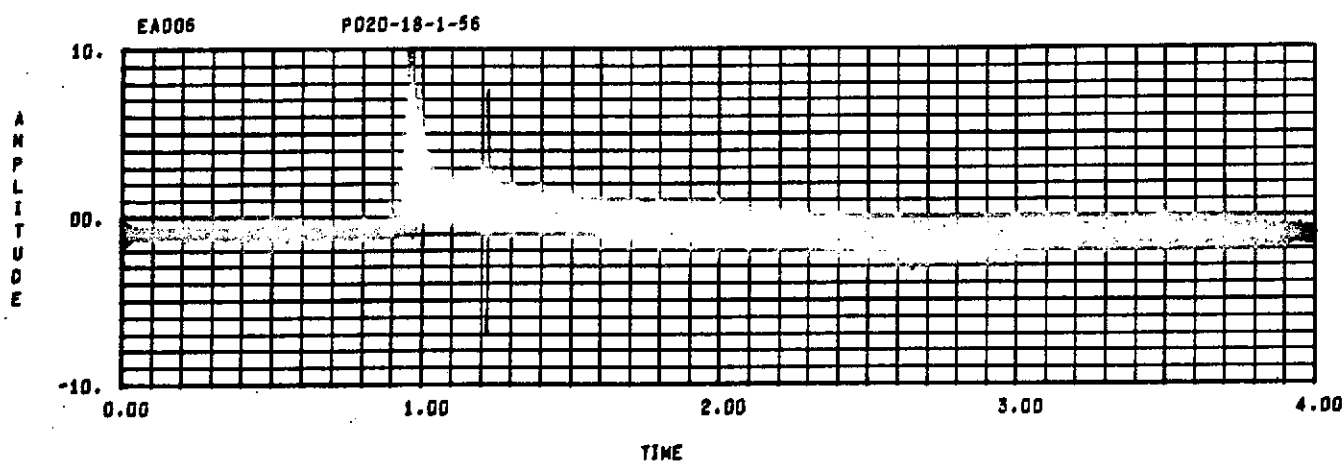
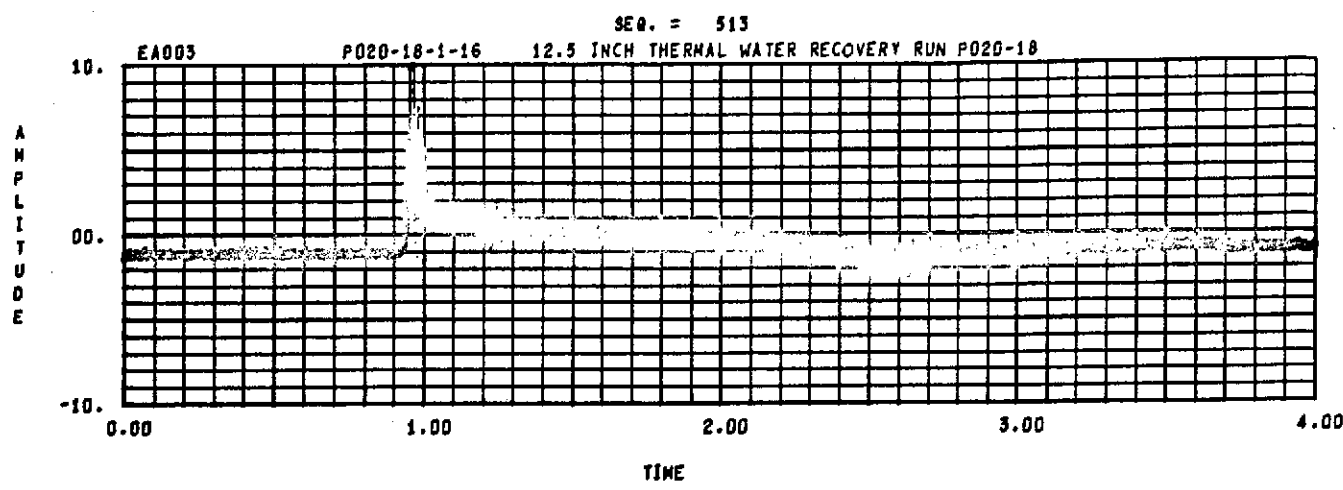






TEST 17 - DATA NOT AVAILABLE

PAGES B-84 THROUGH B-90
ARE LEFT OUT INTENTIONALLY

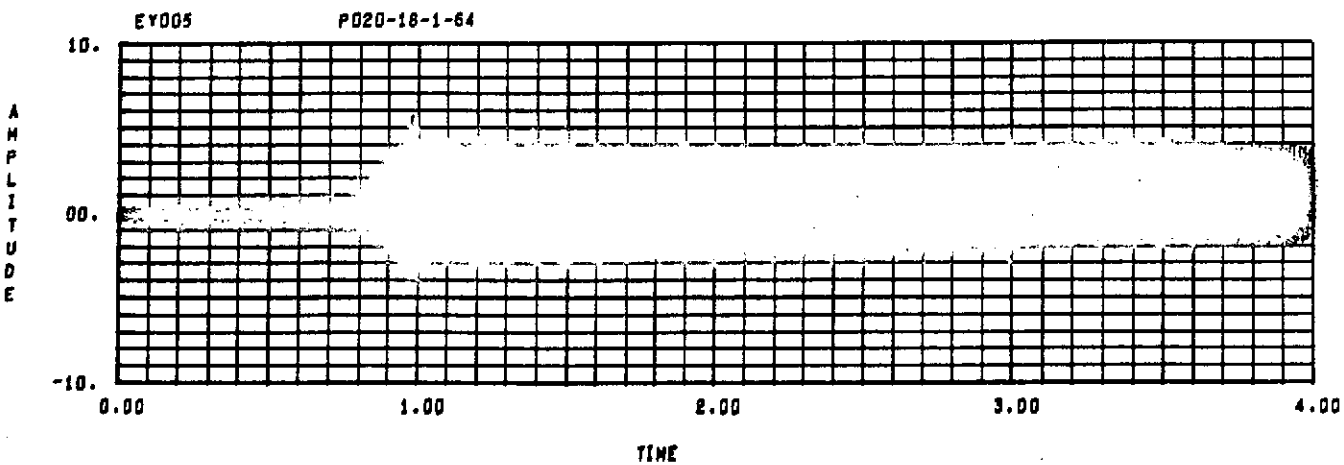
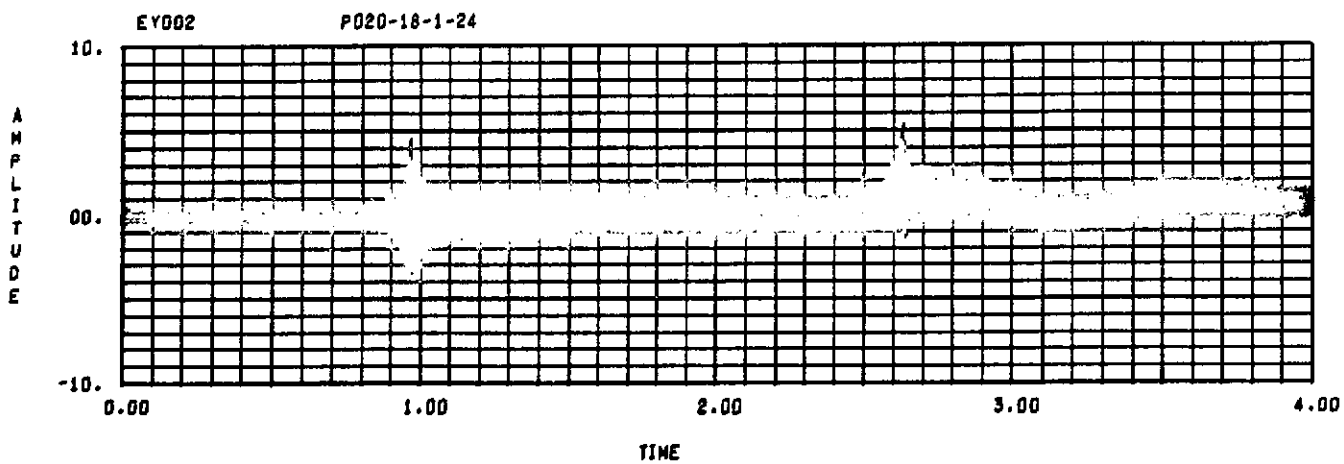
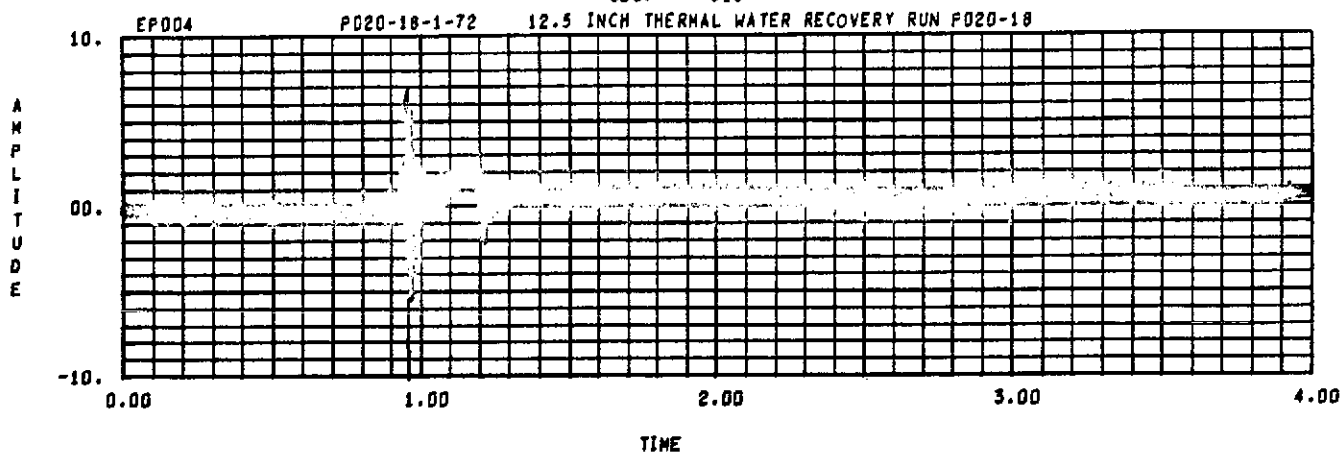


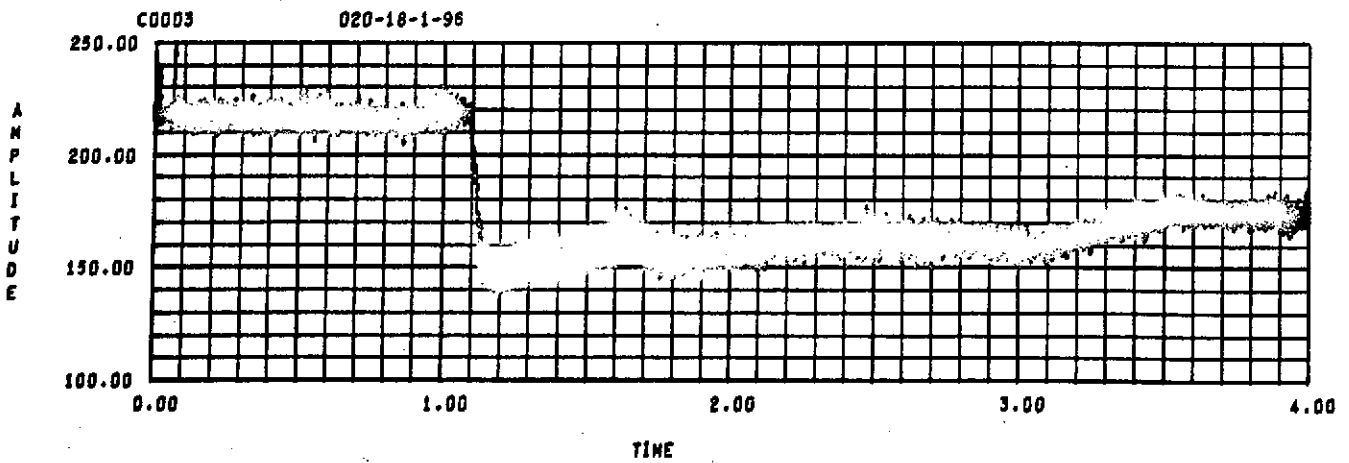
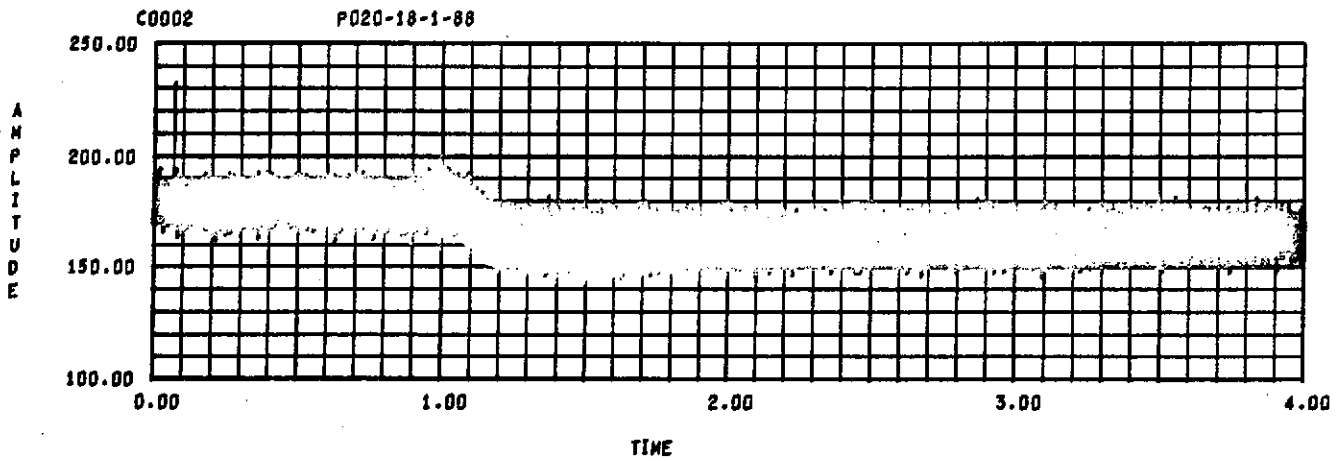
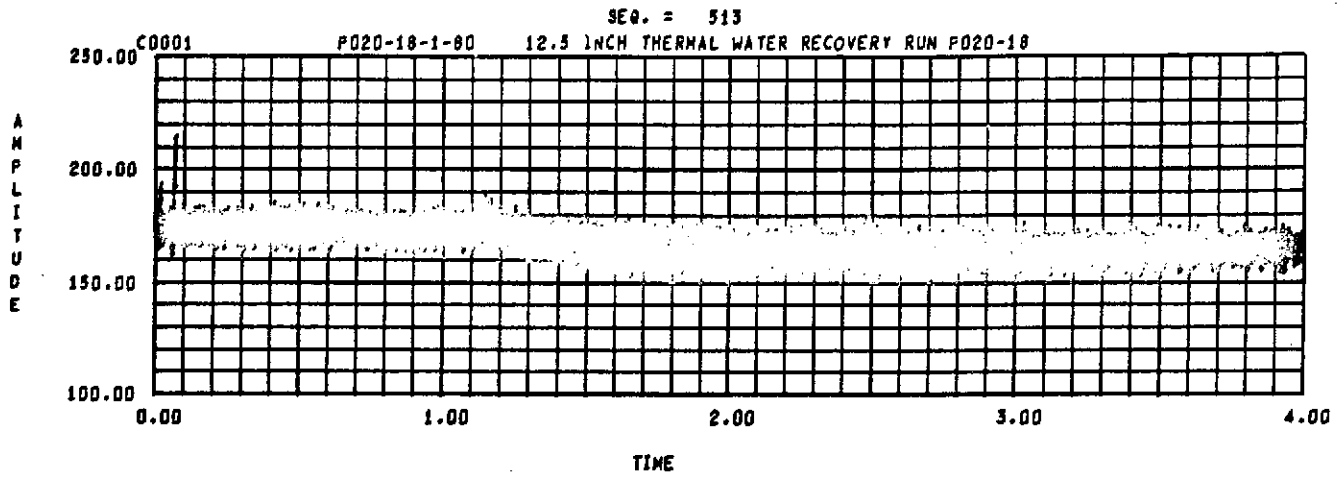
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B-91

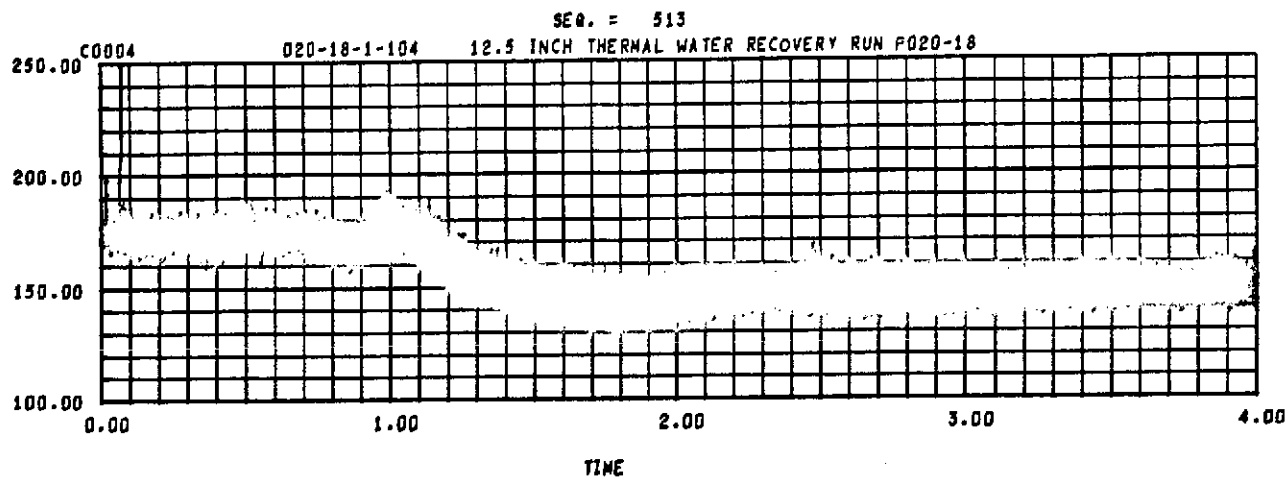
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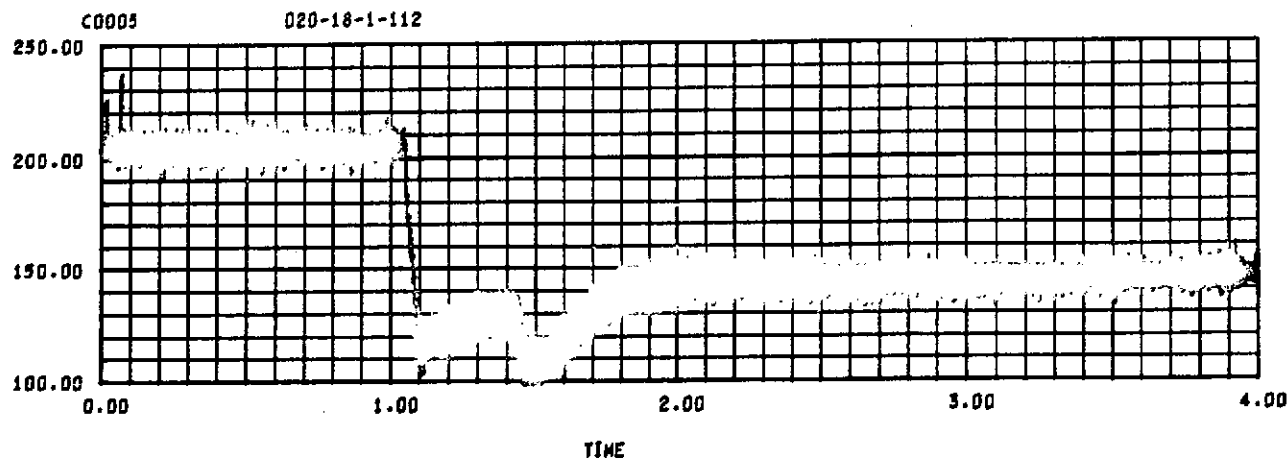




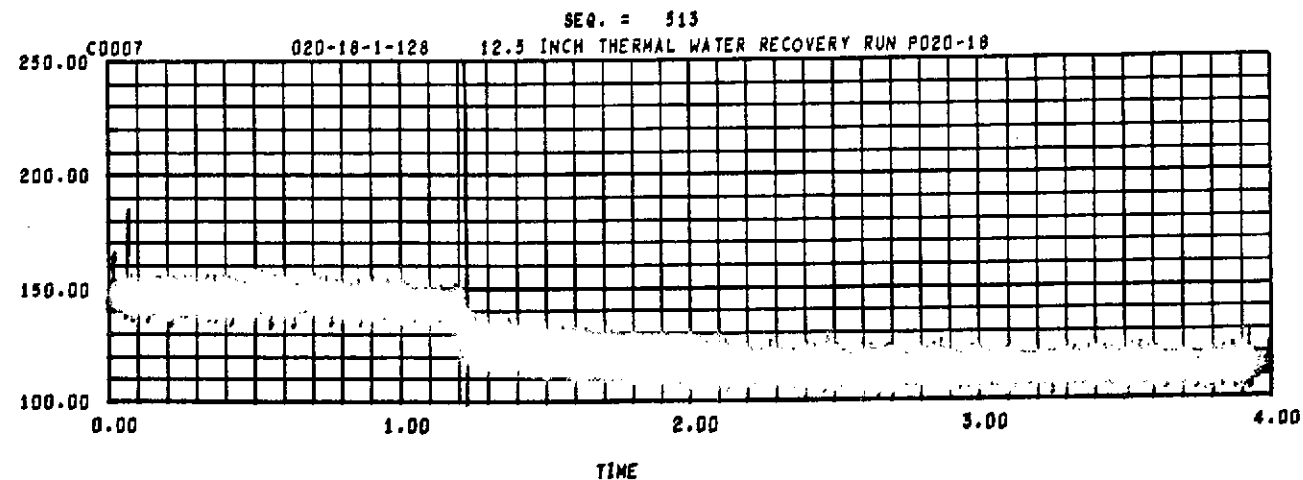
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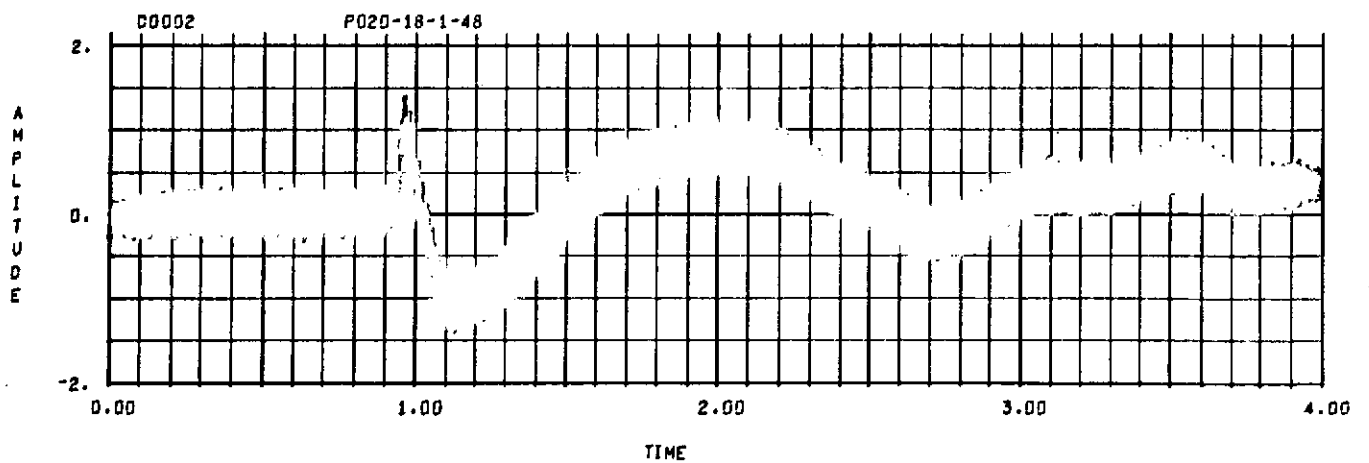
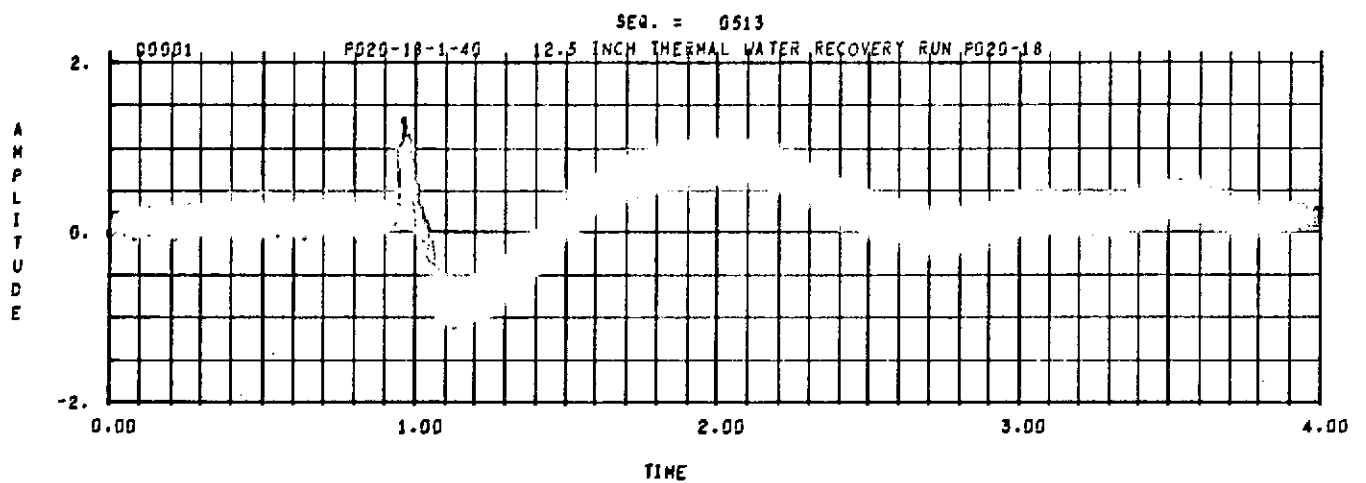
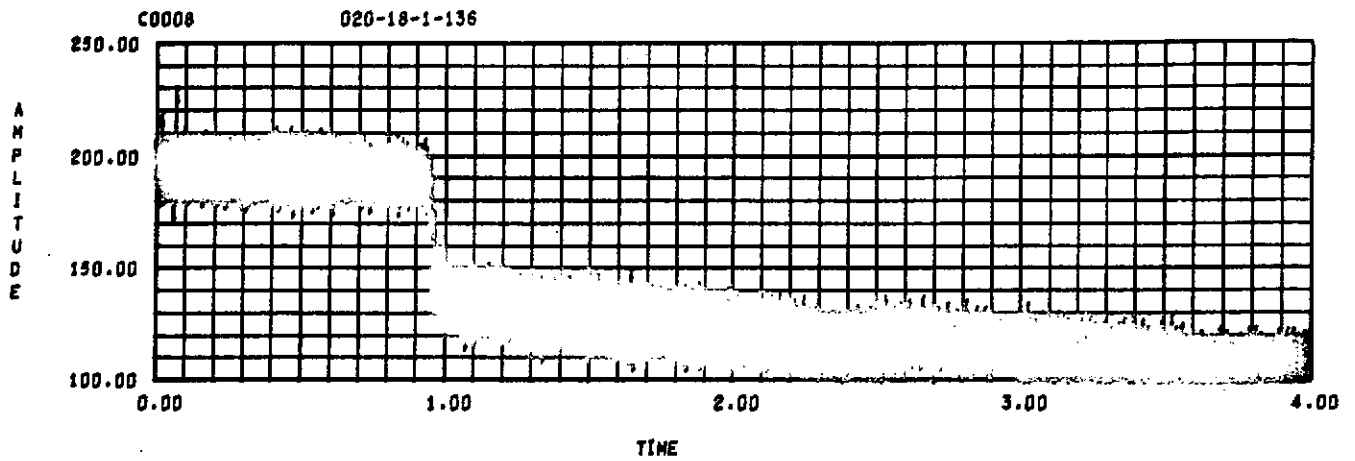


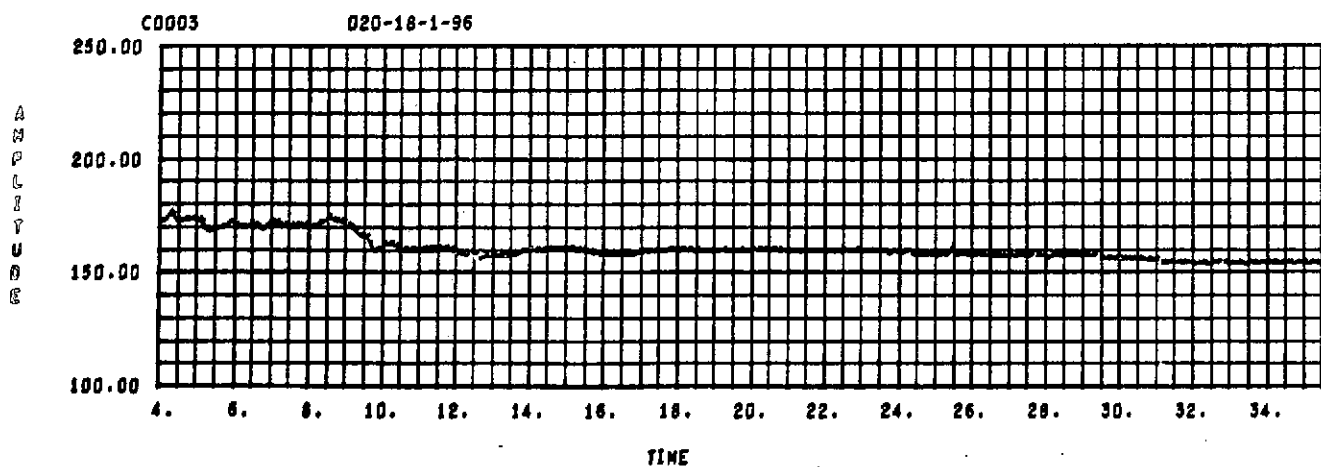
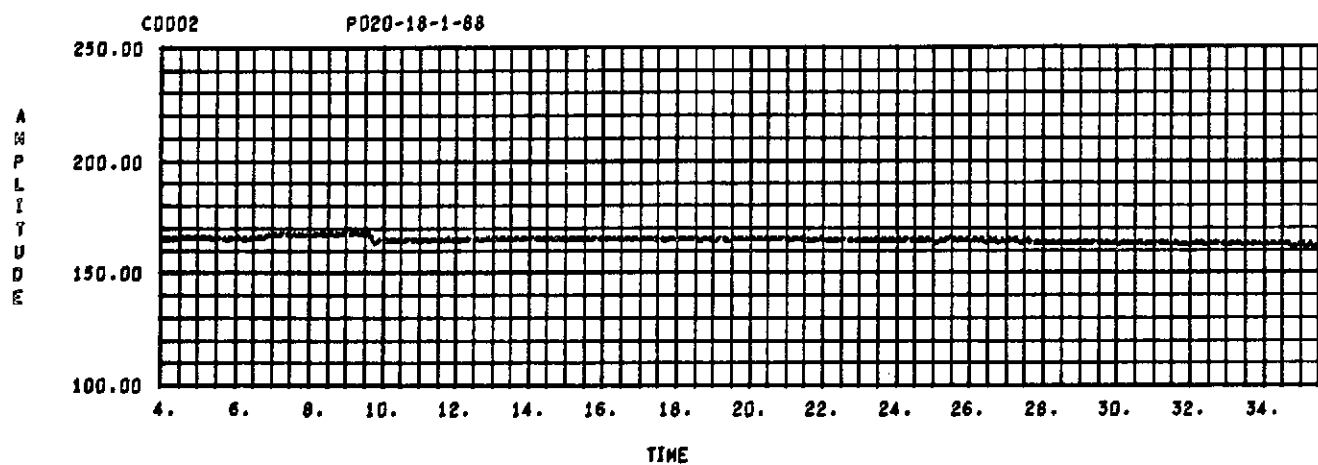
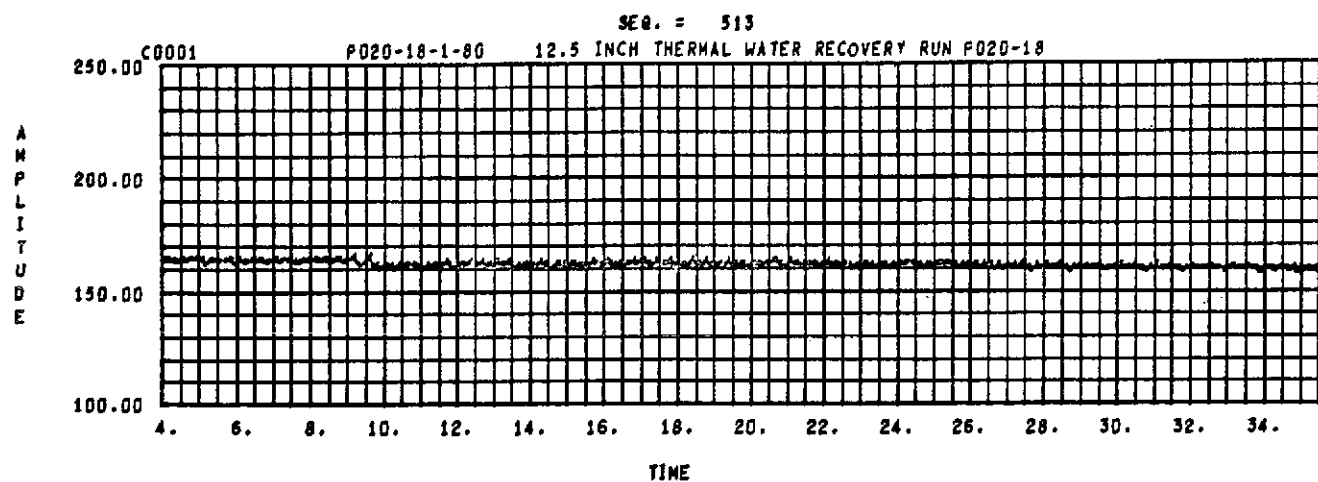
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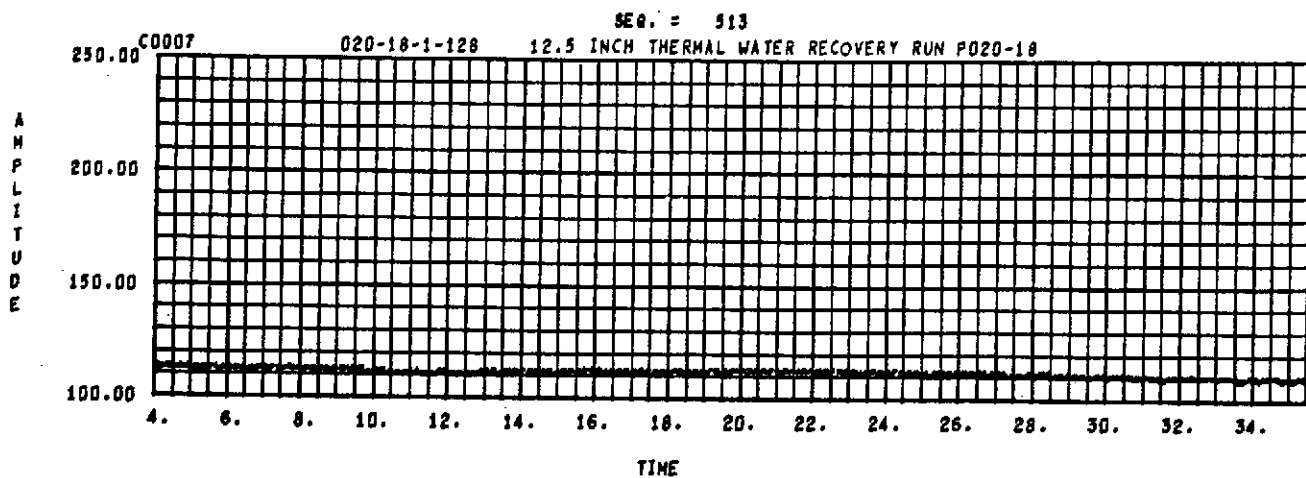
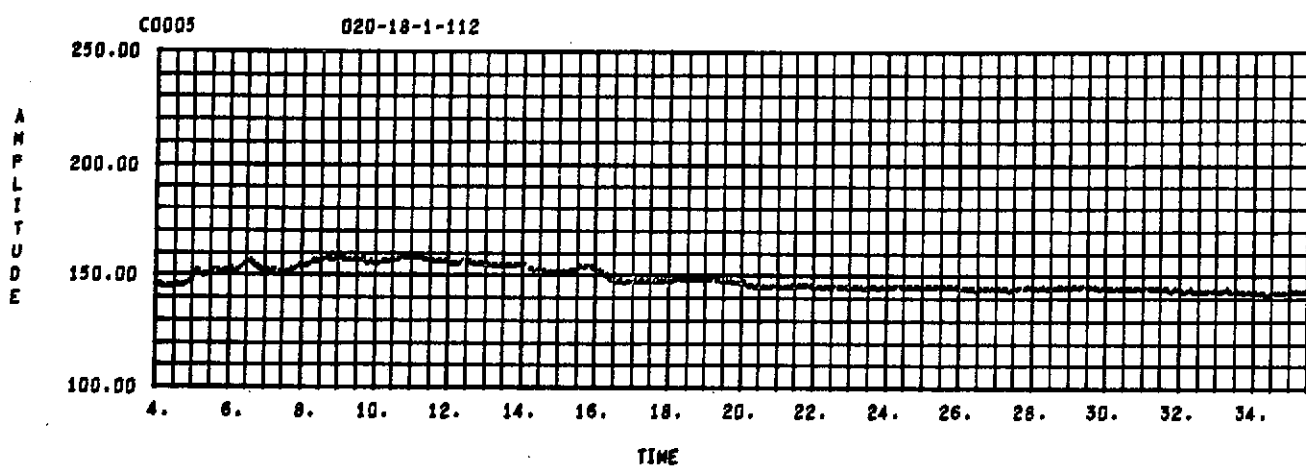
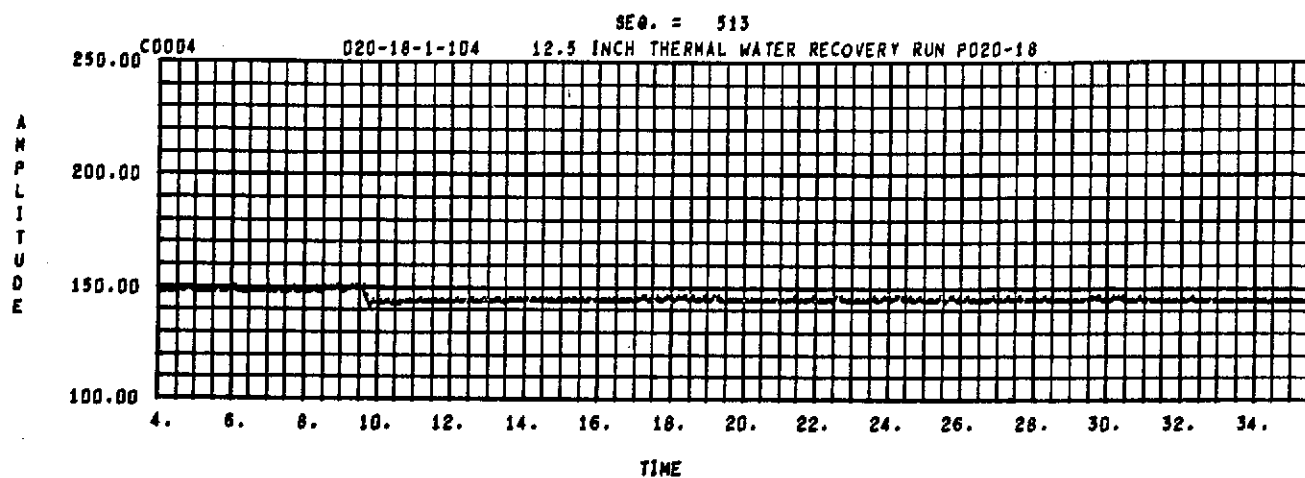


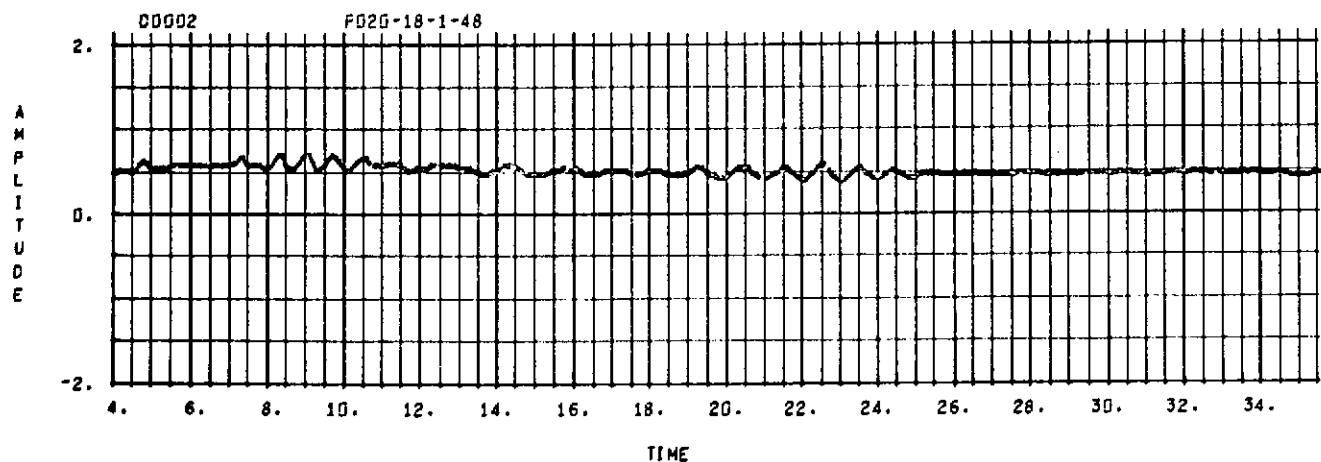
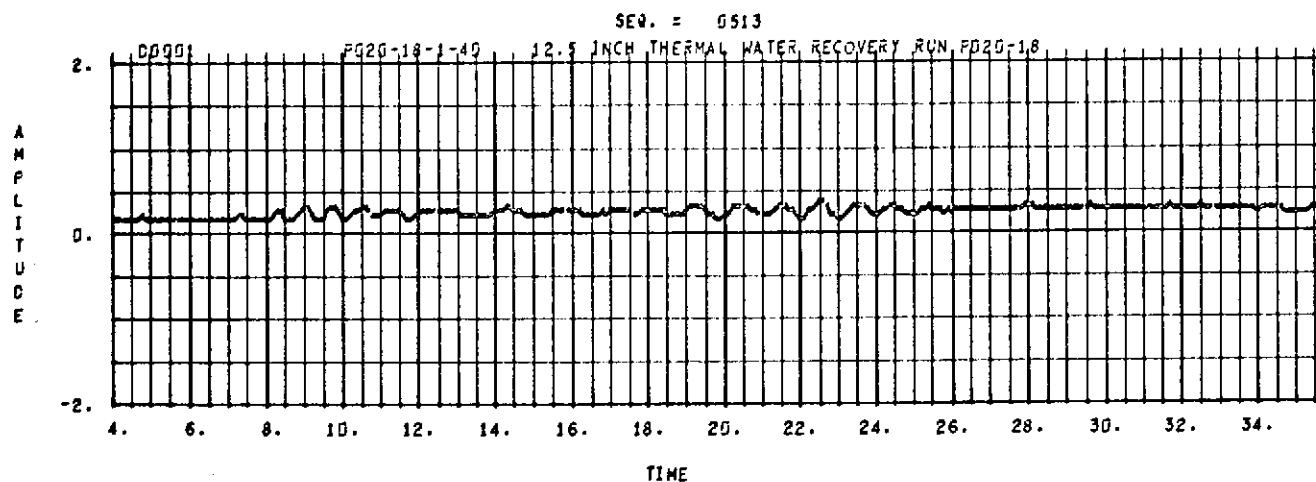
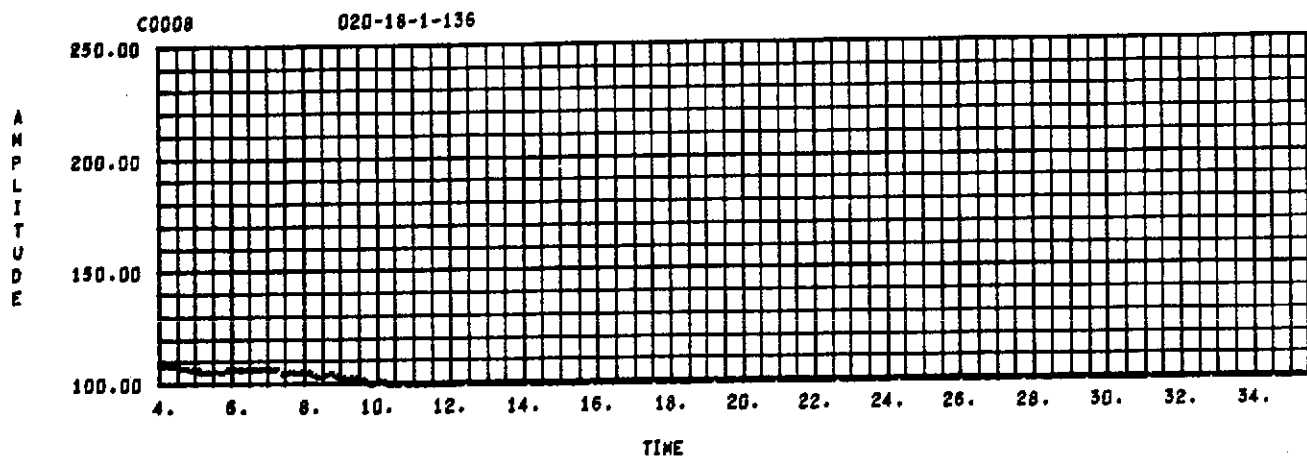
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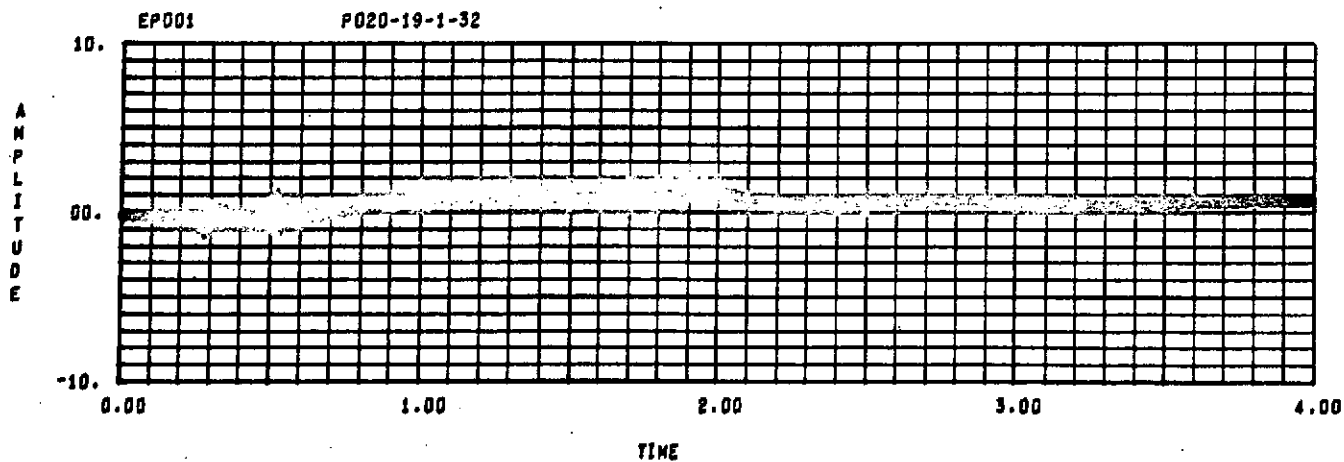
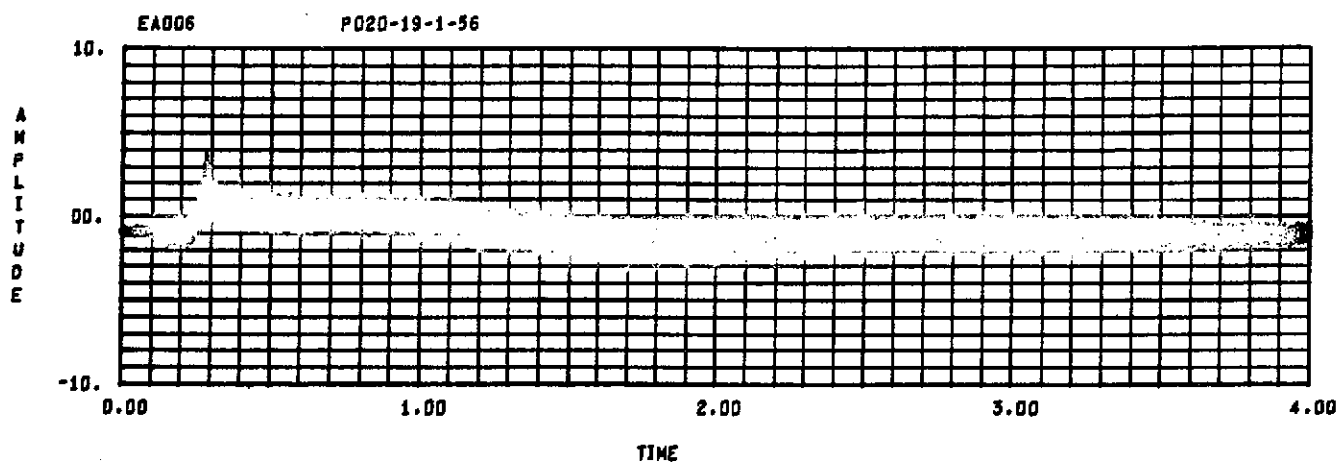
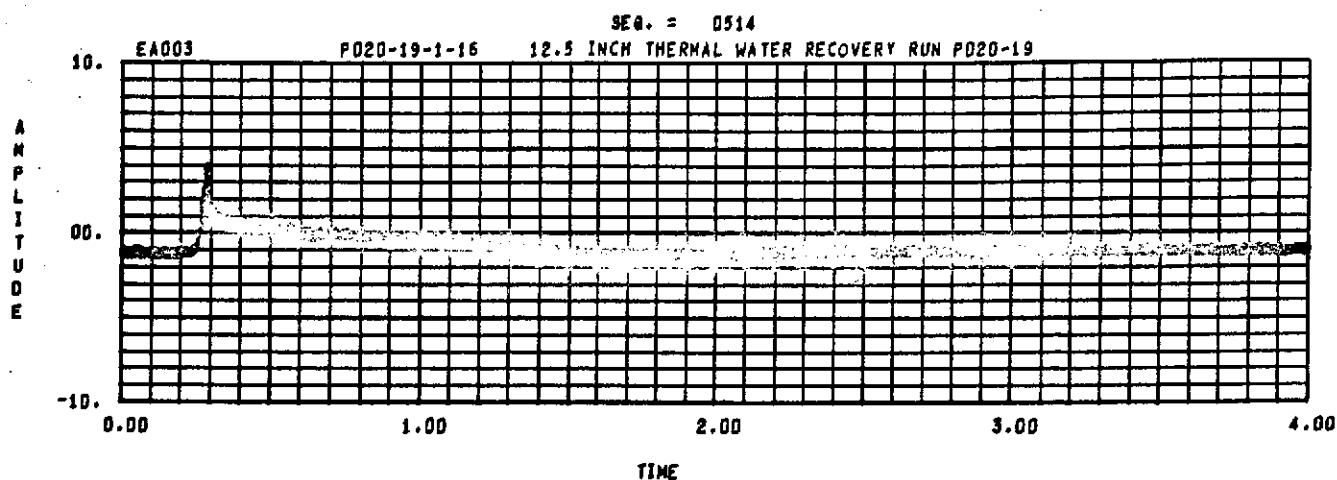




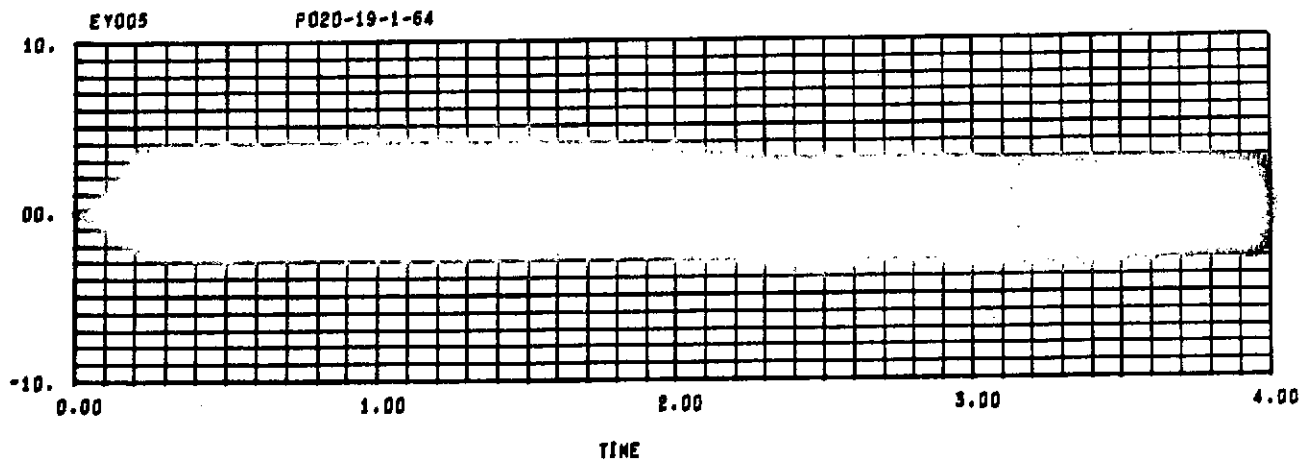
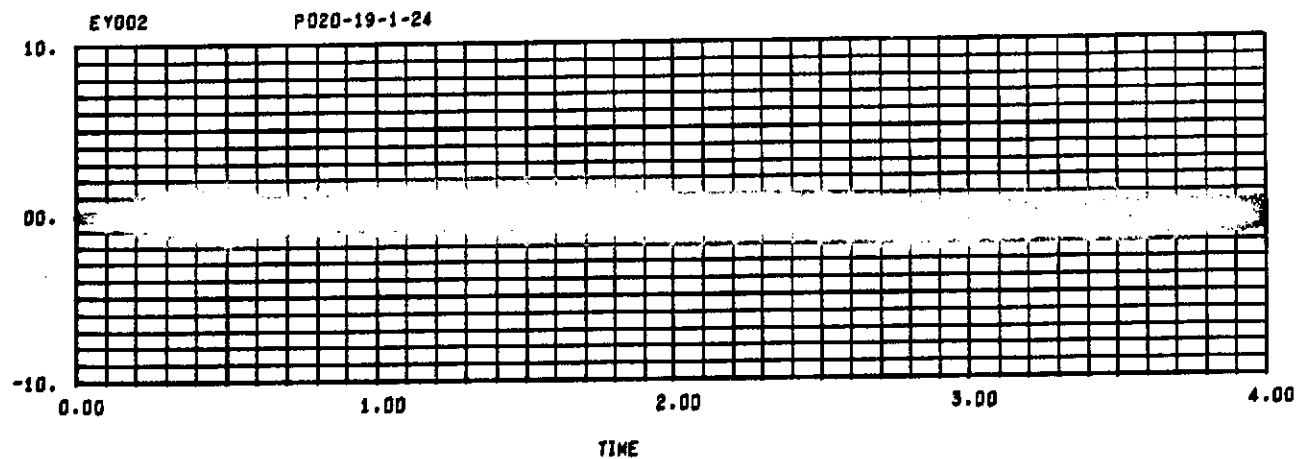
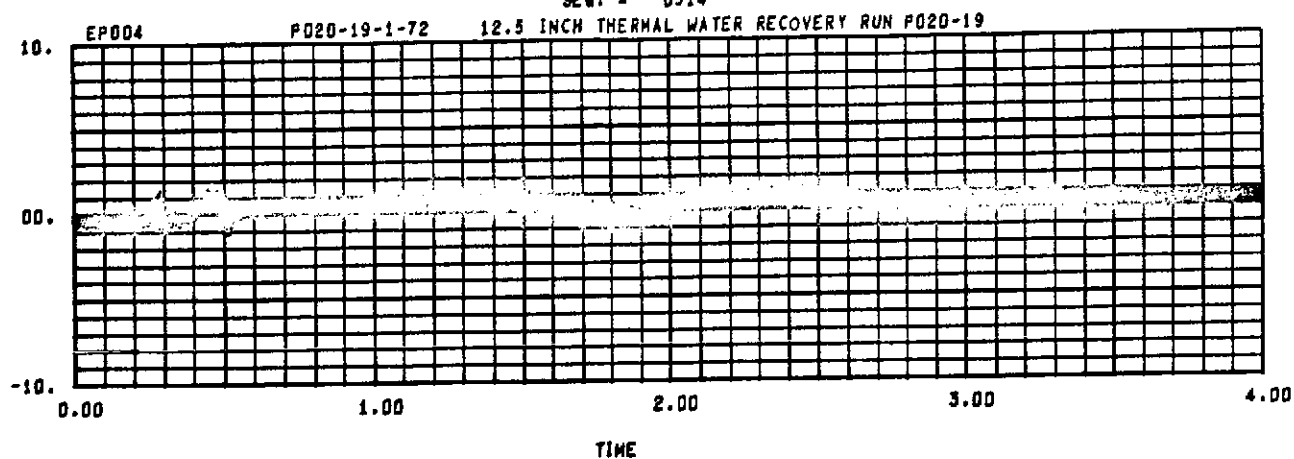


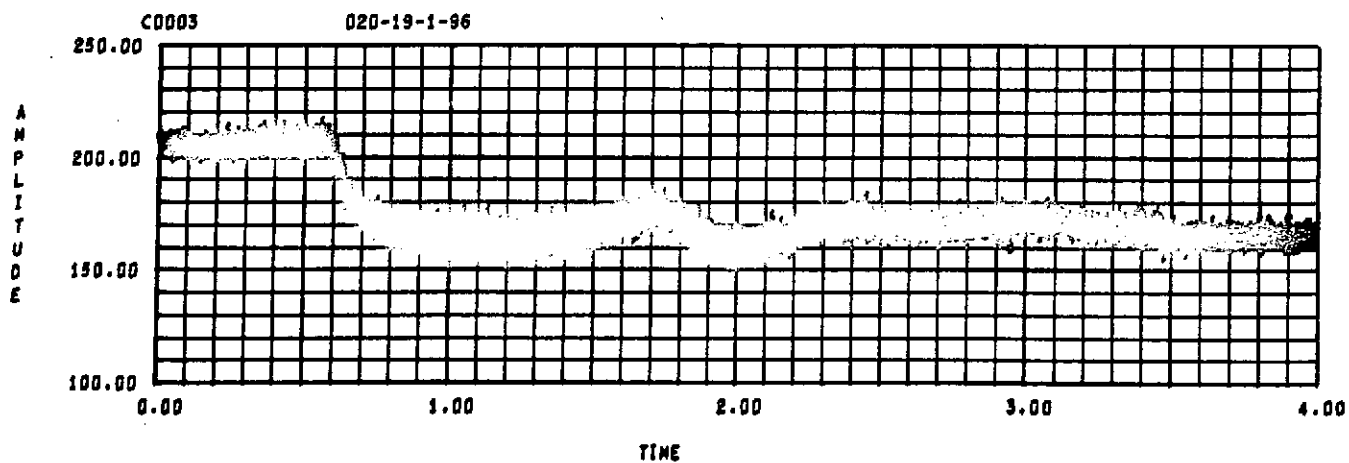
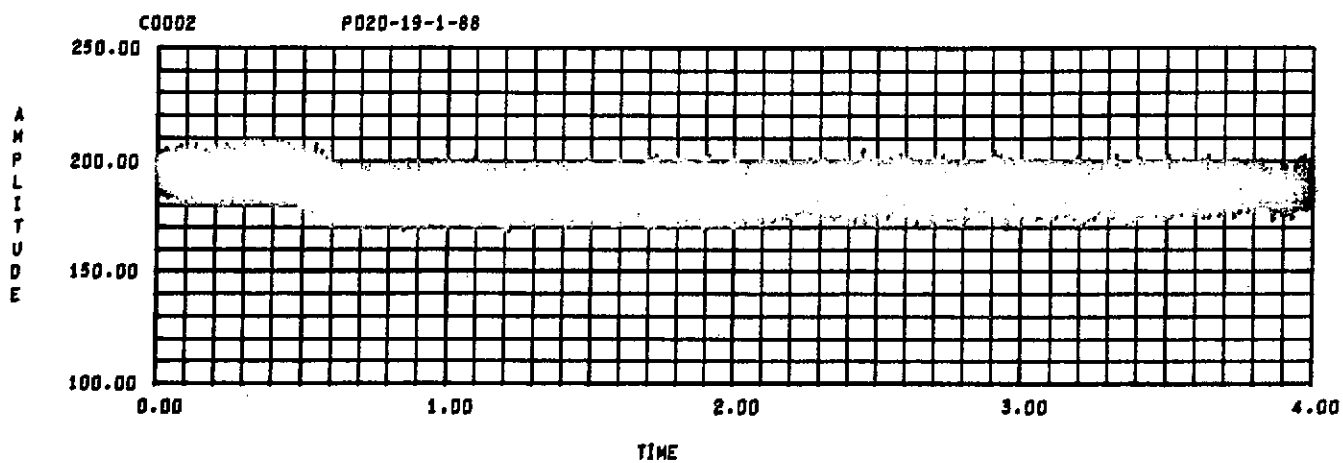
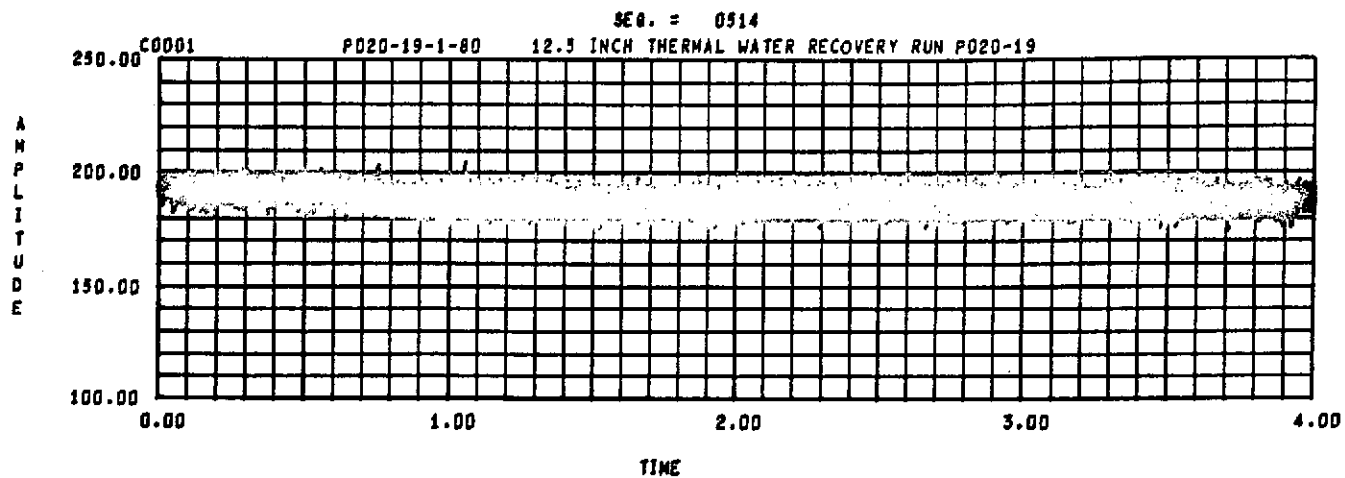




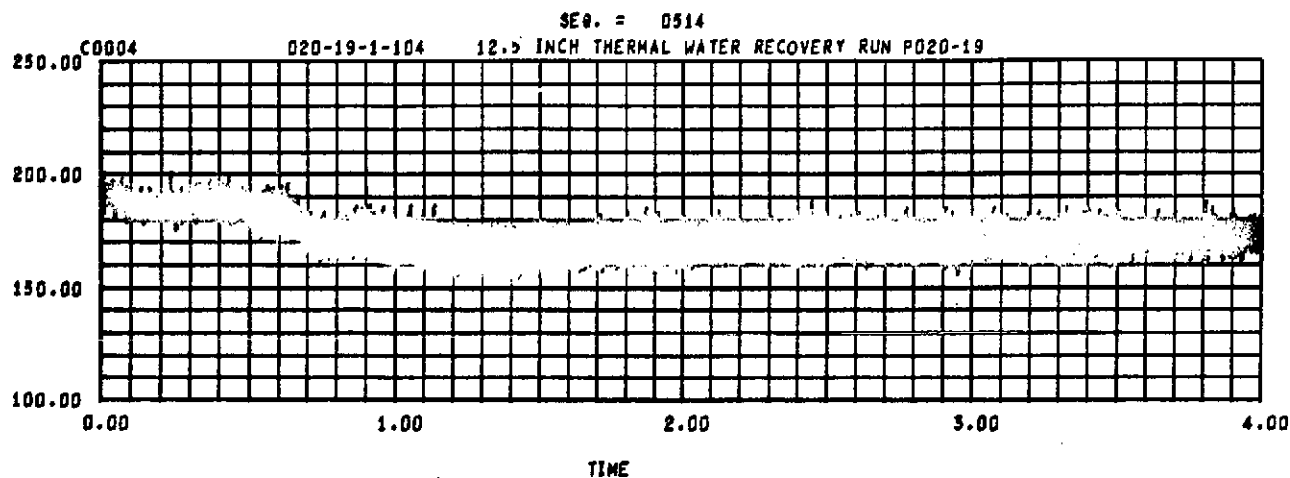


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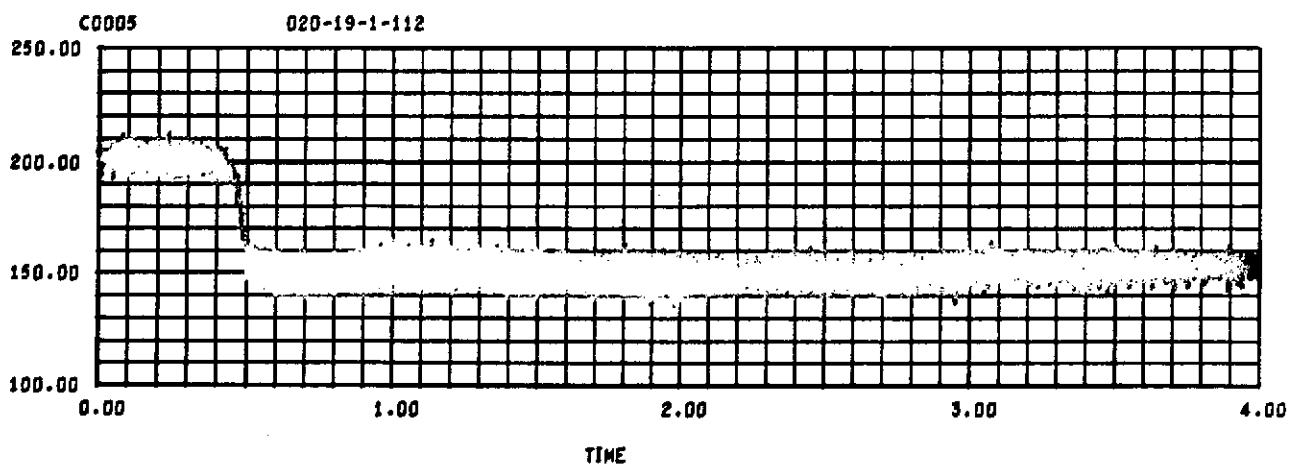




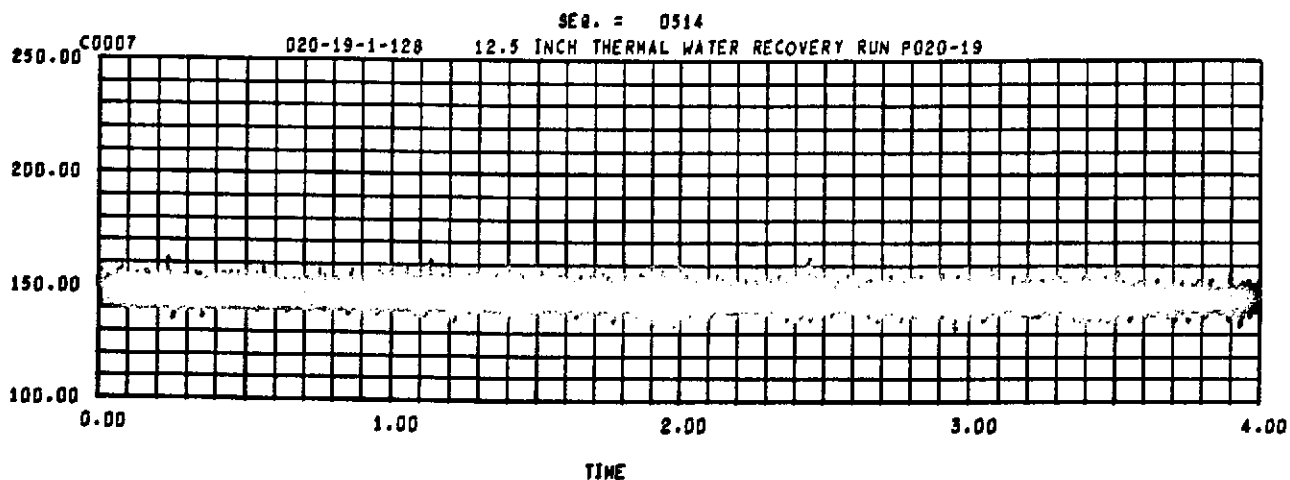
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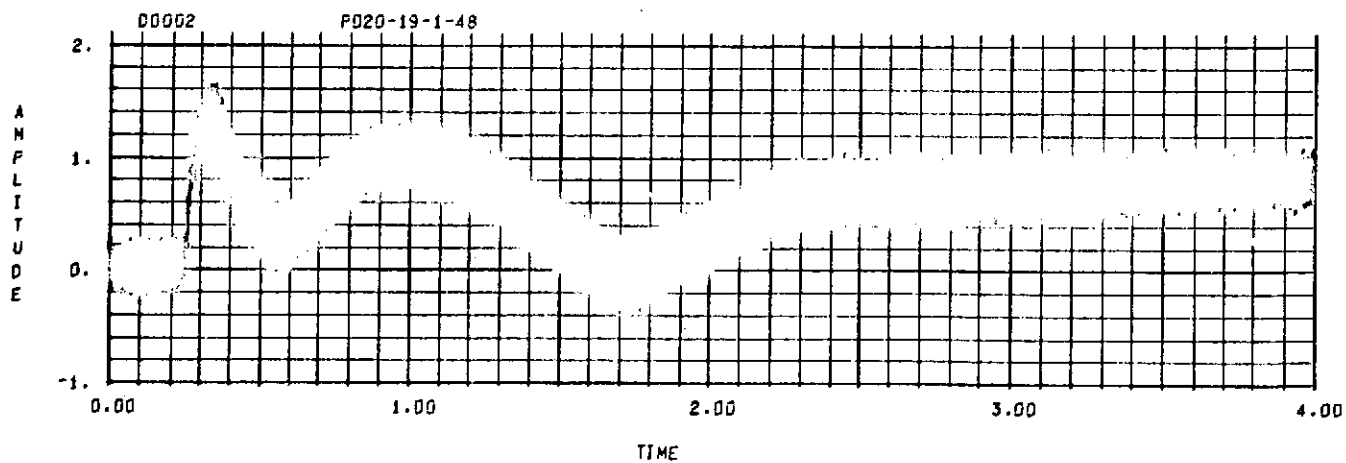
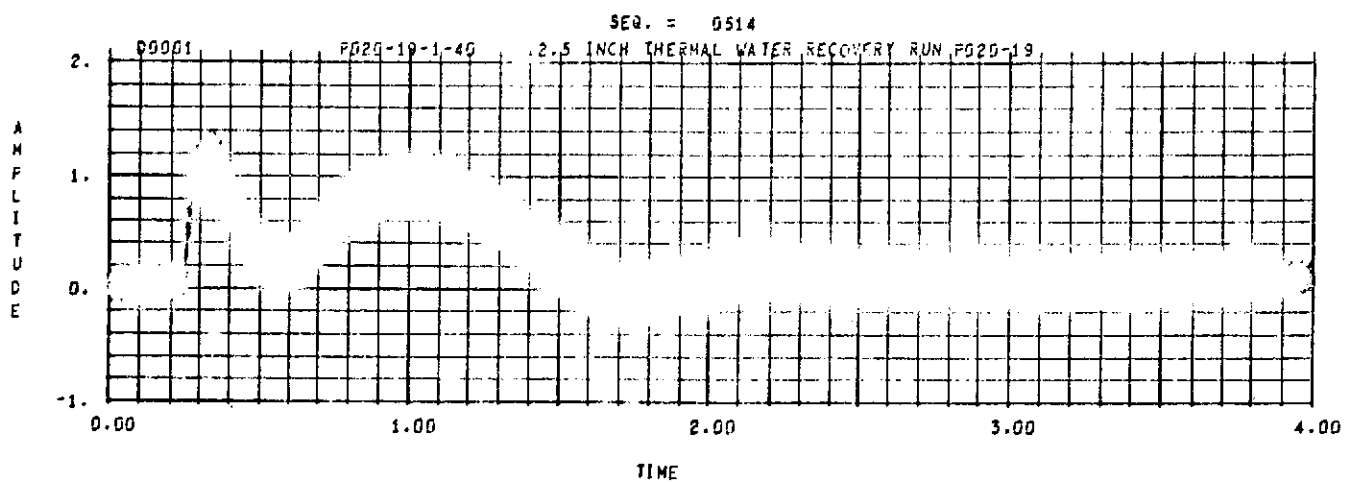
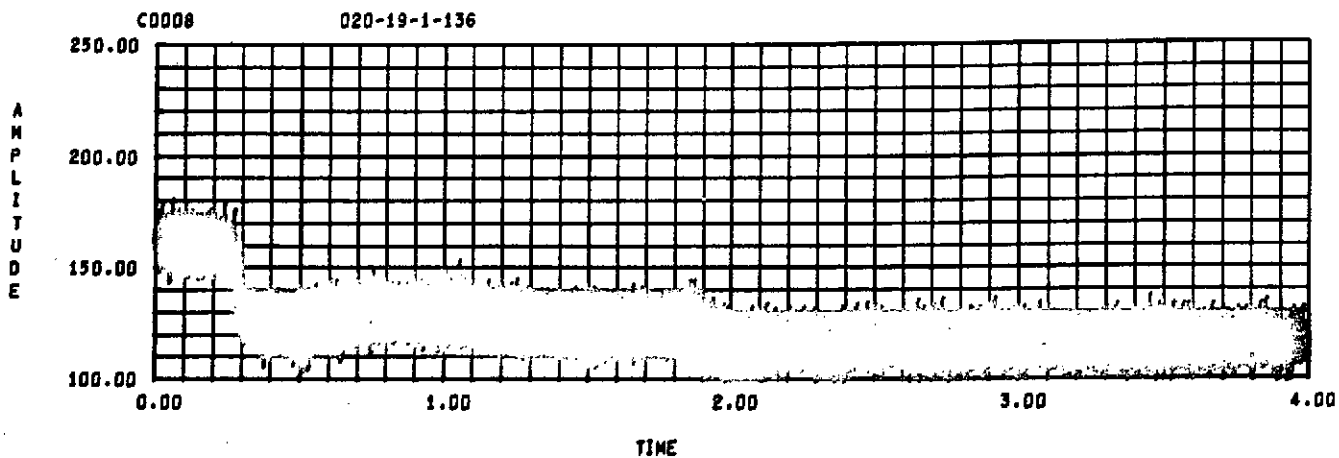


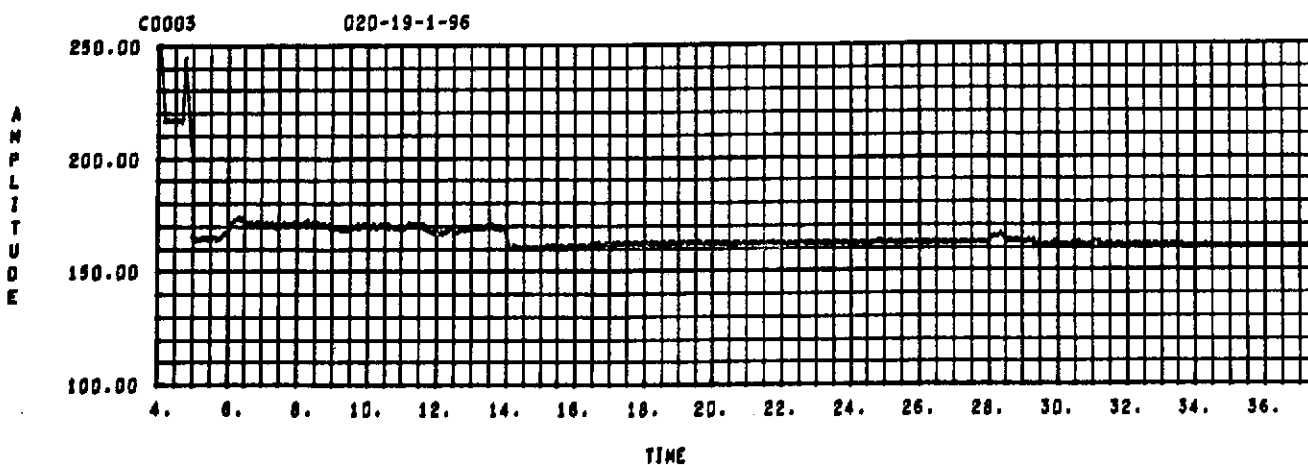
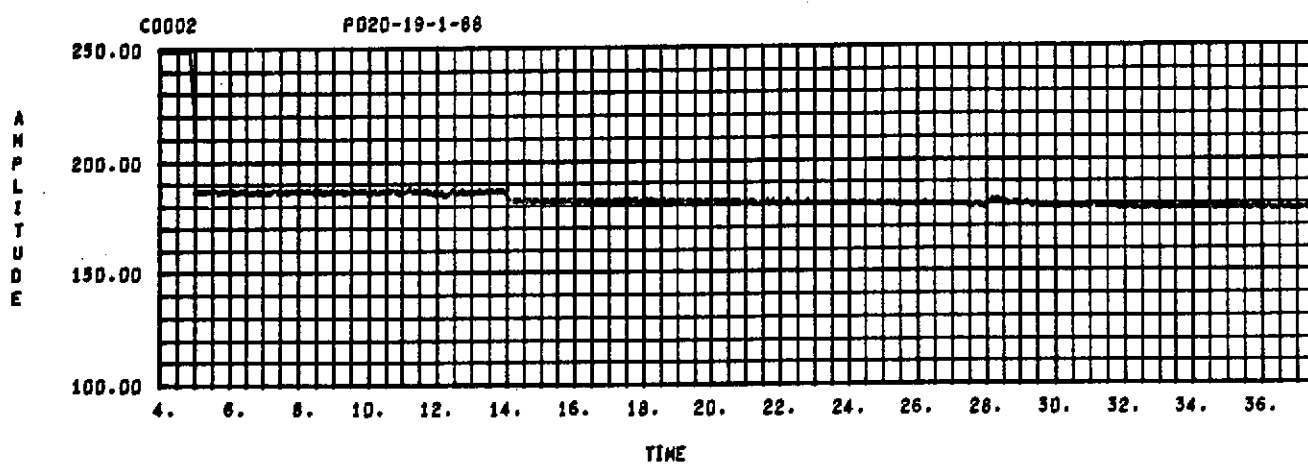
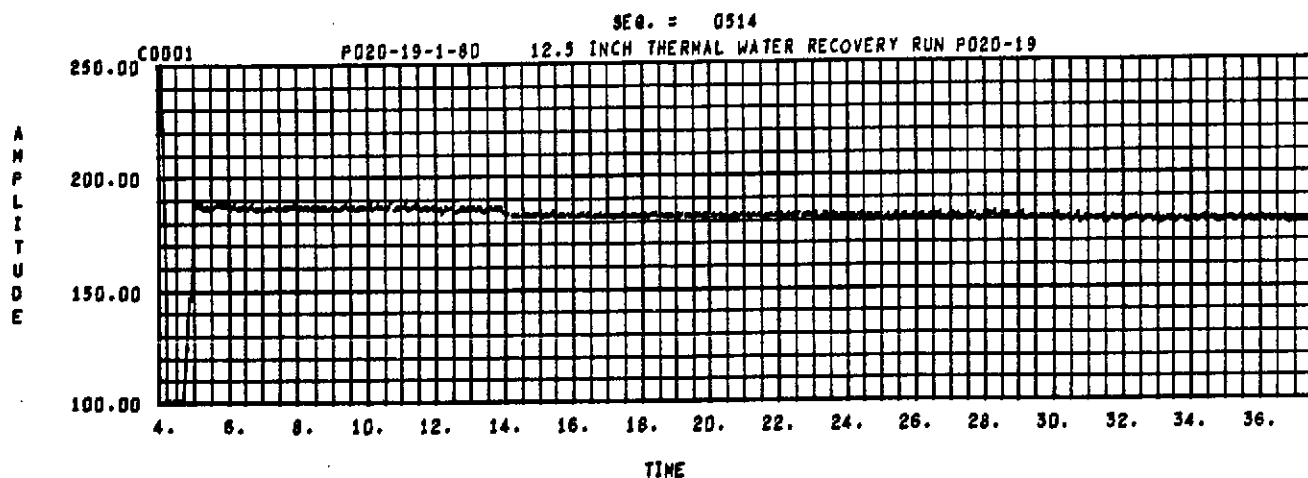
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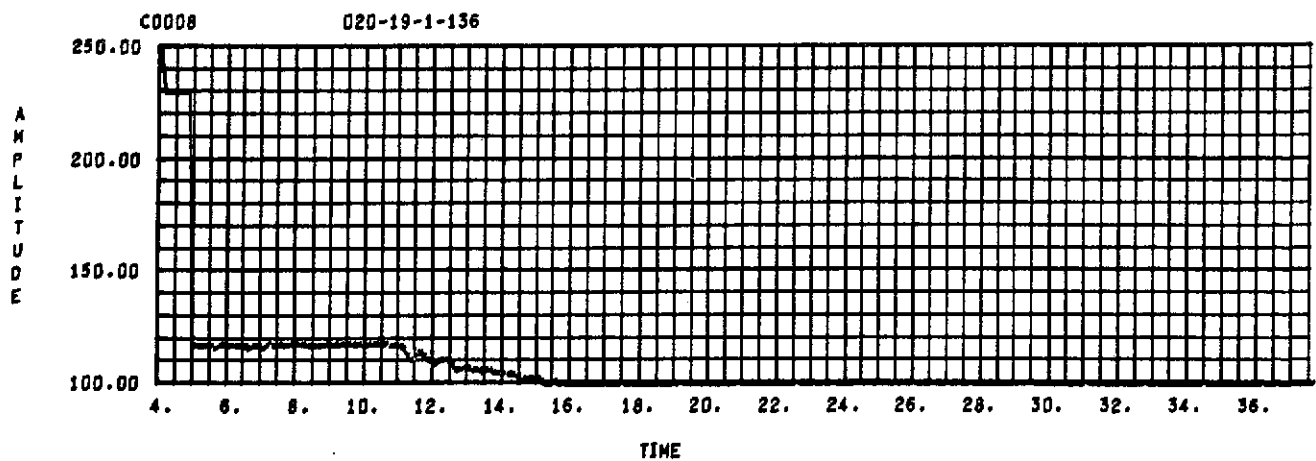
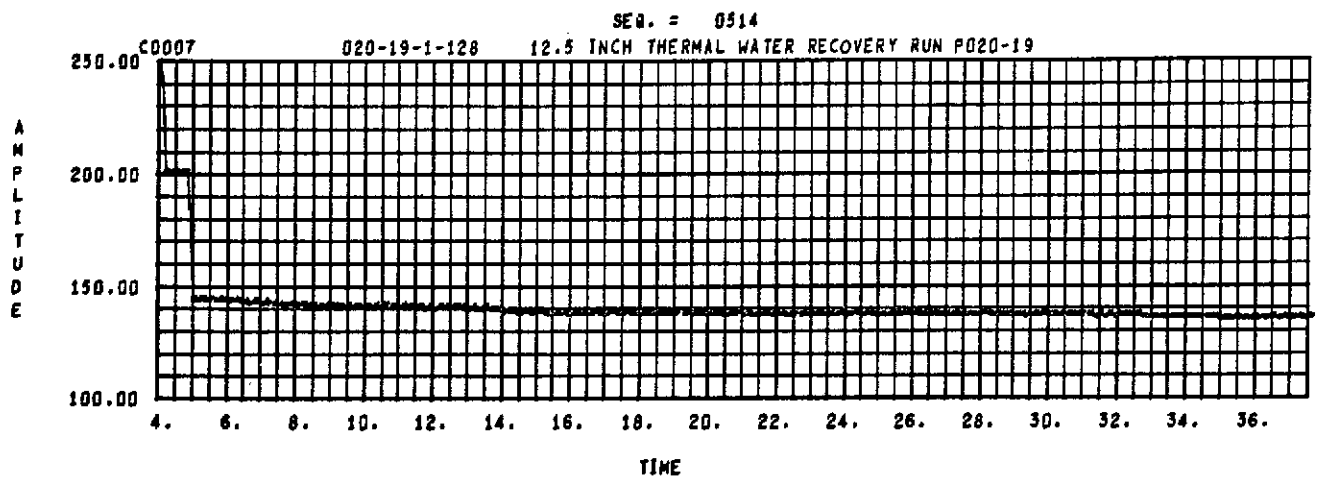
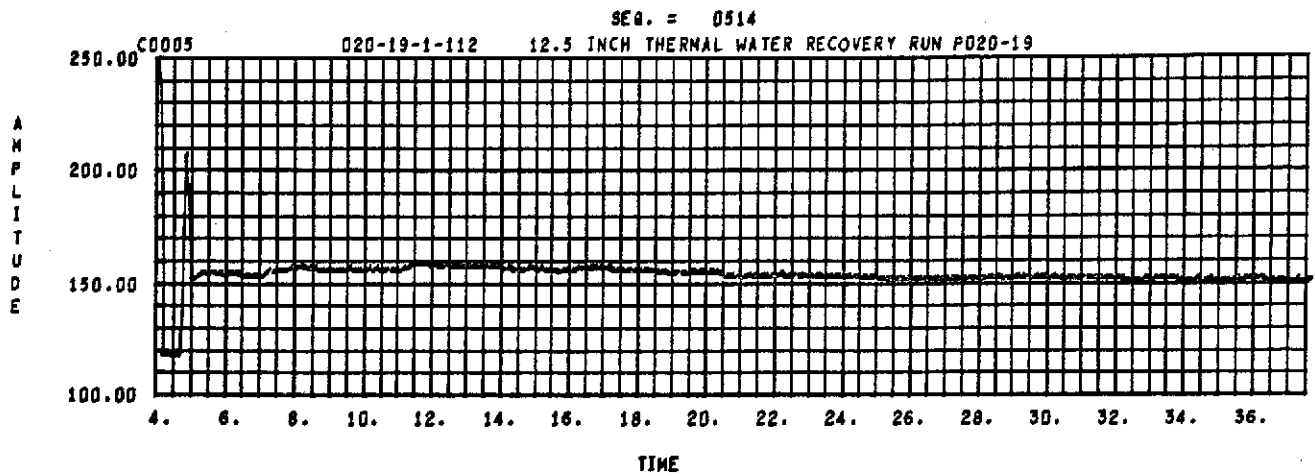


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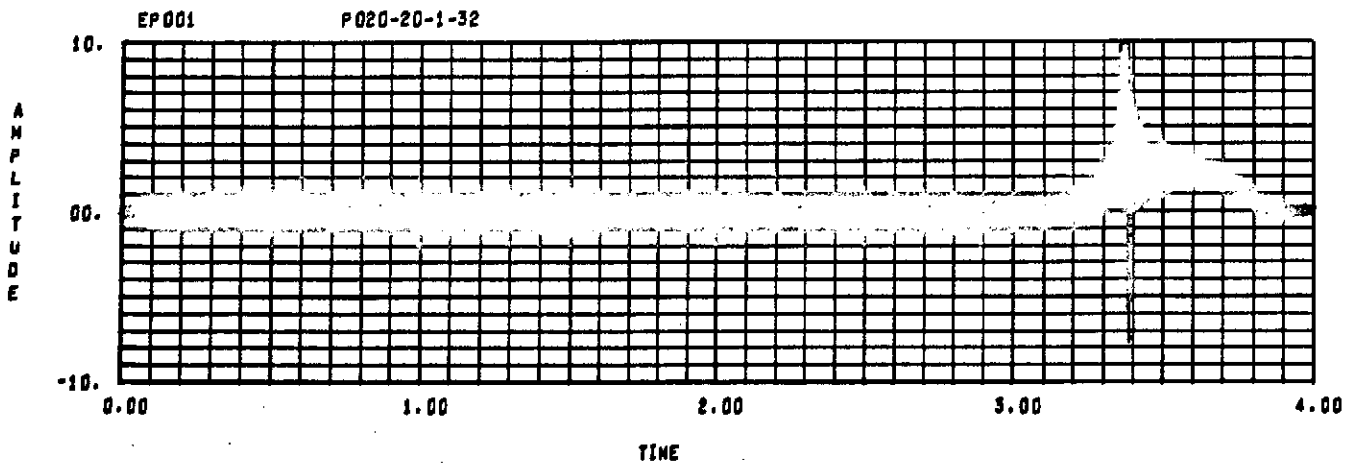
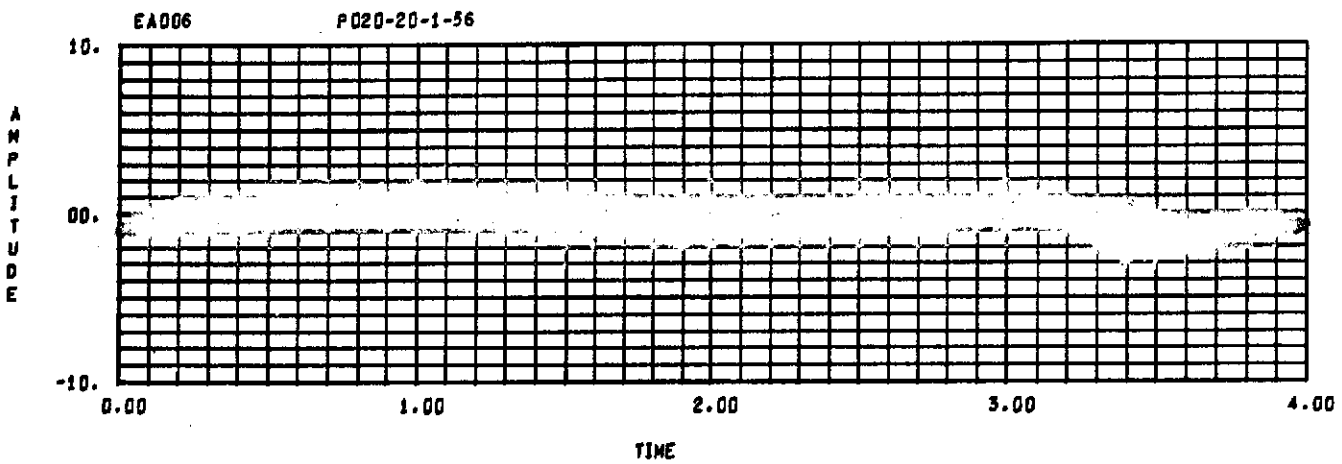
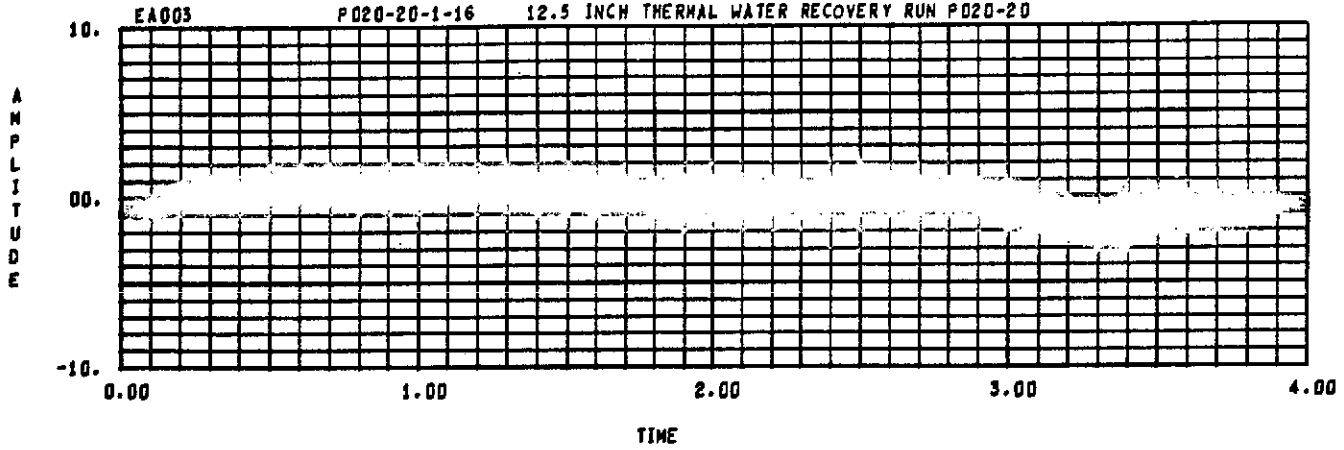


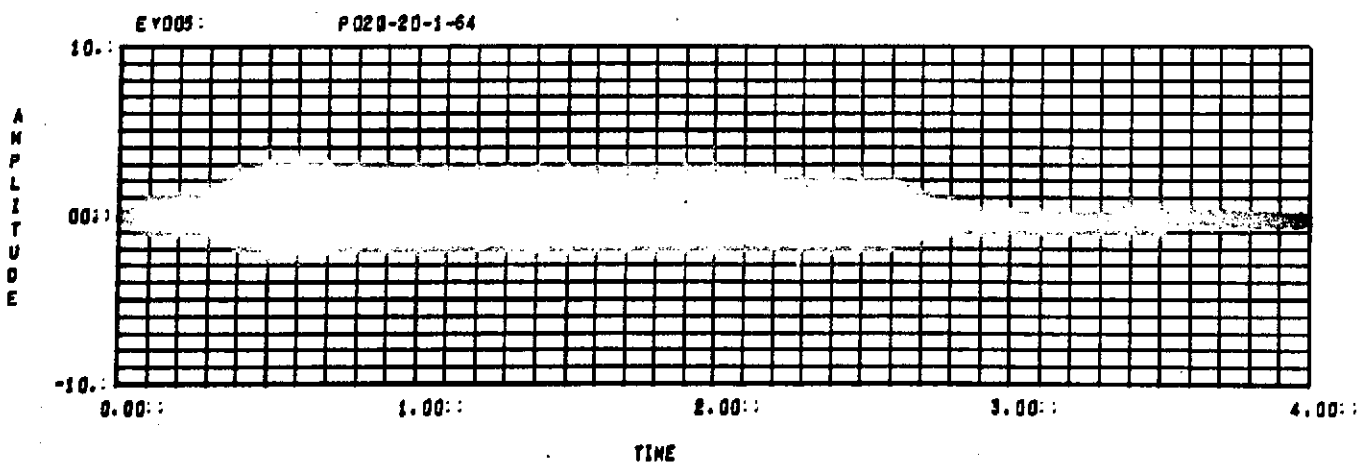
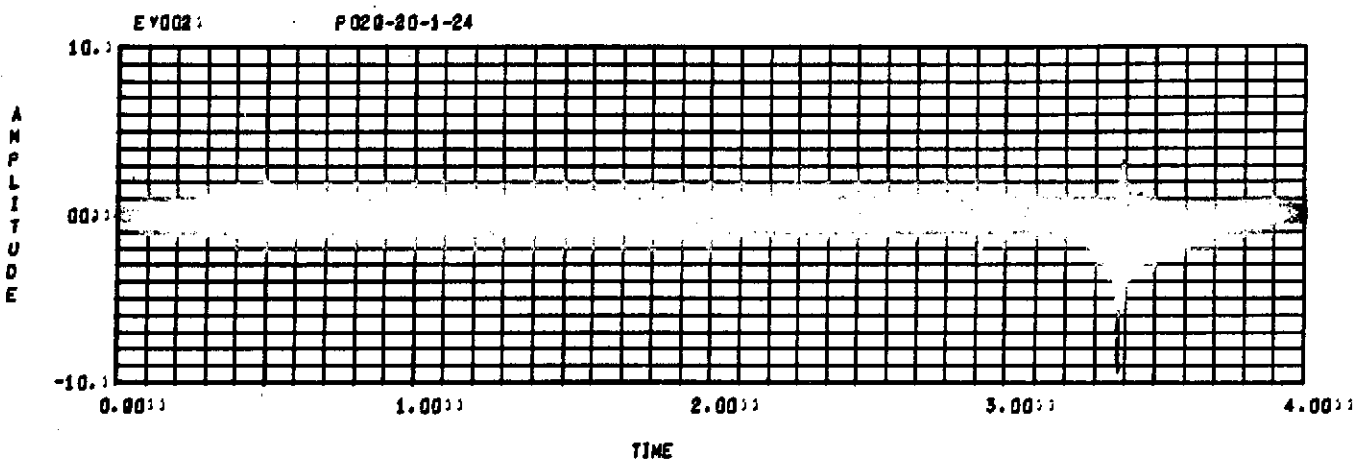
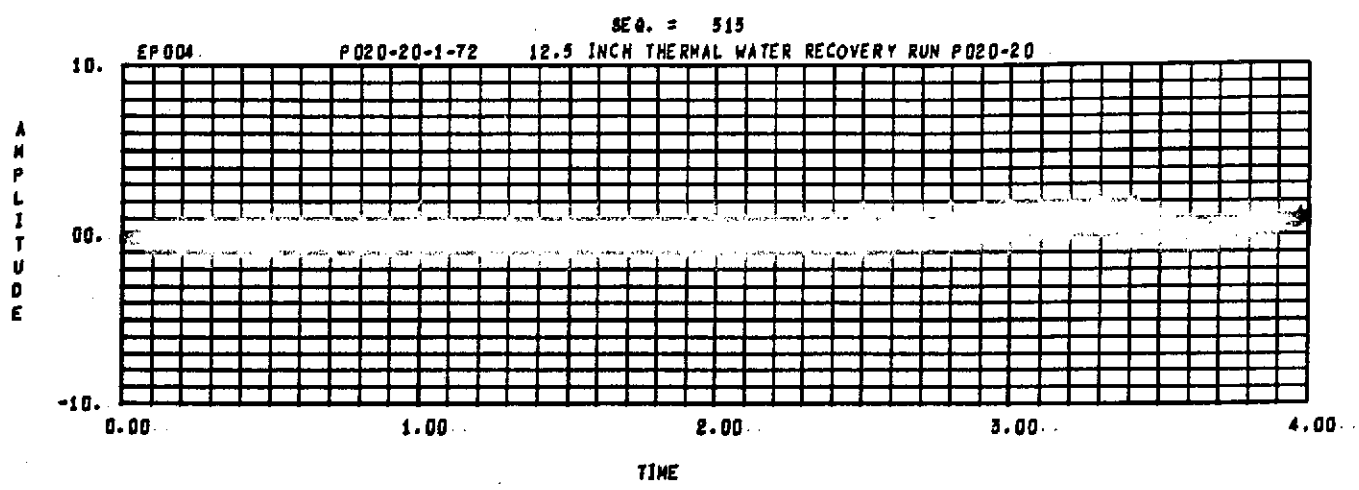




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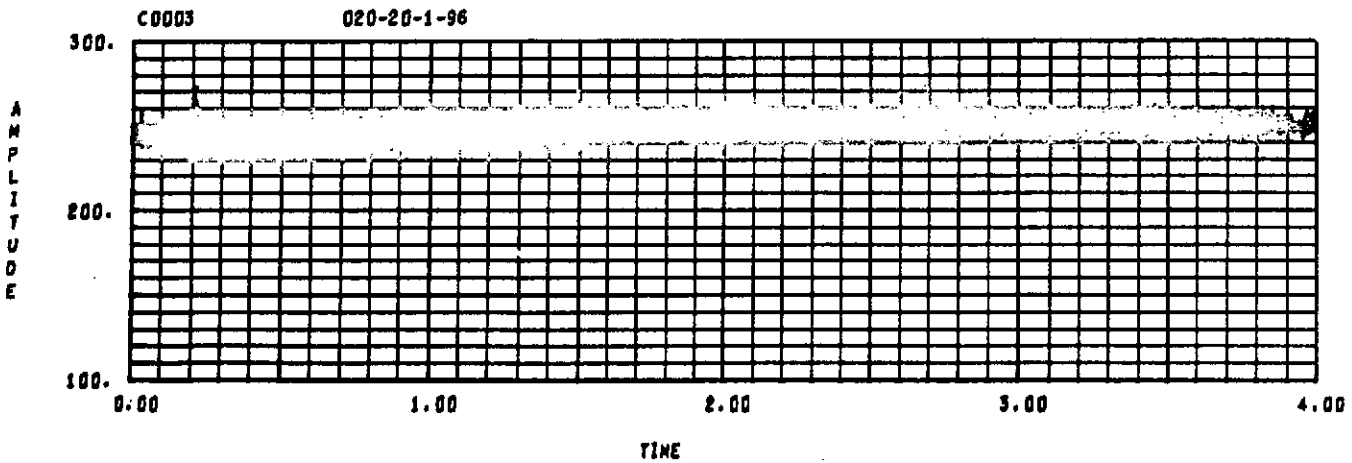
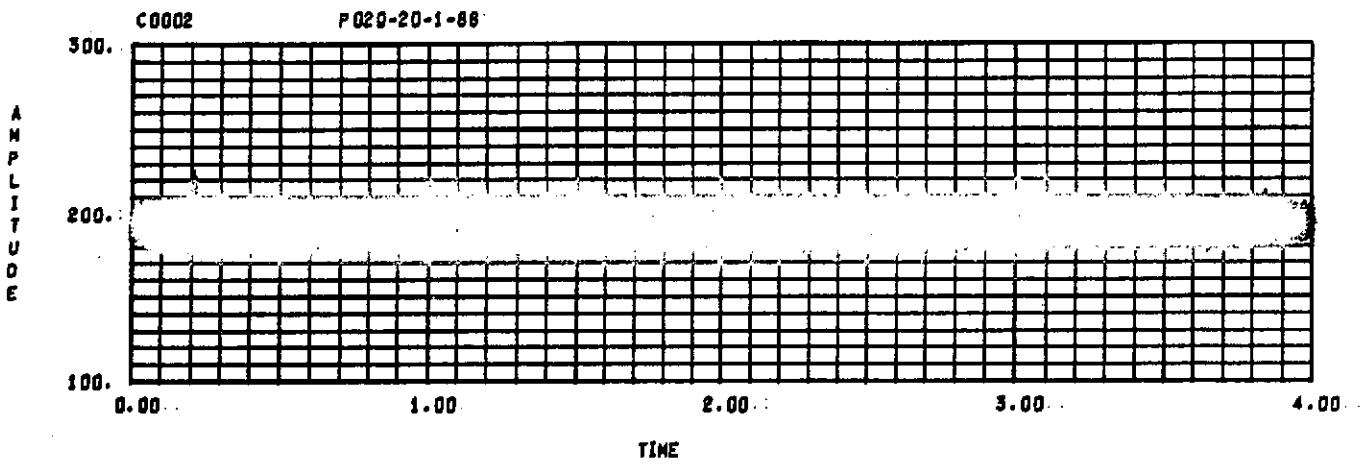
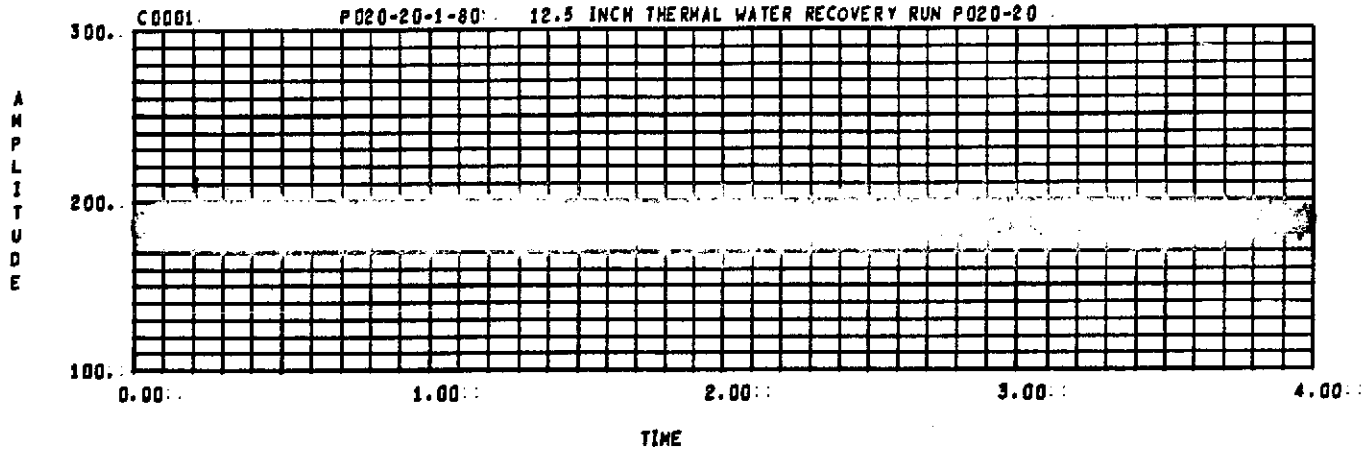
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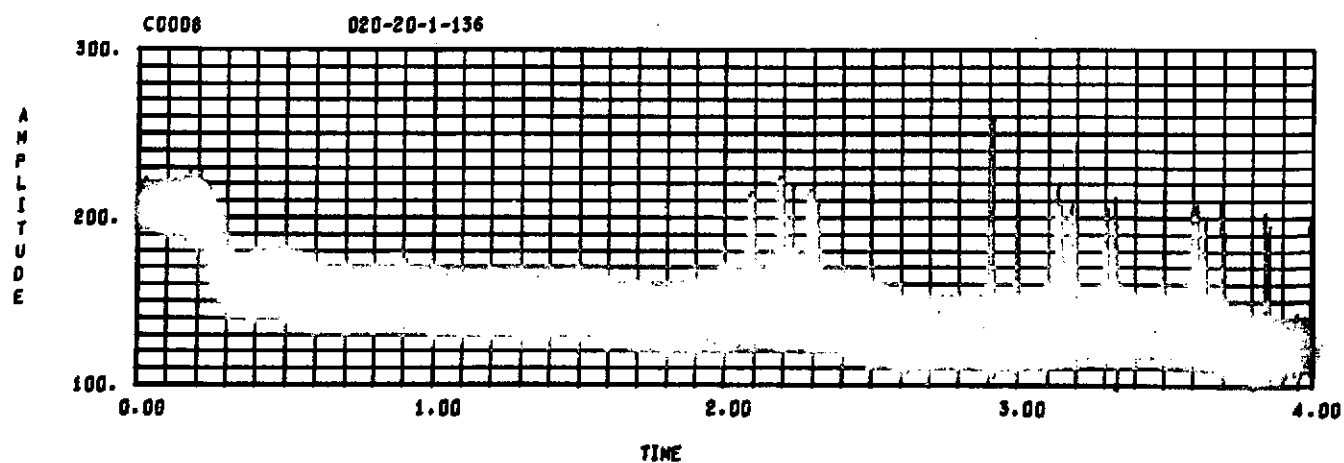
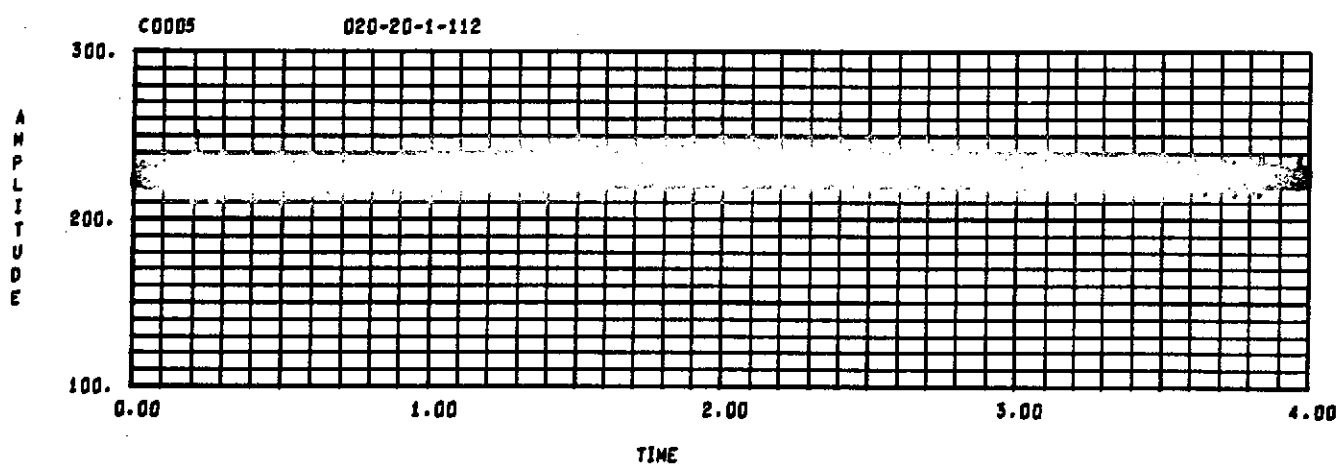
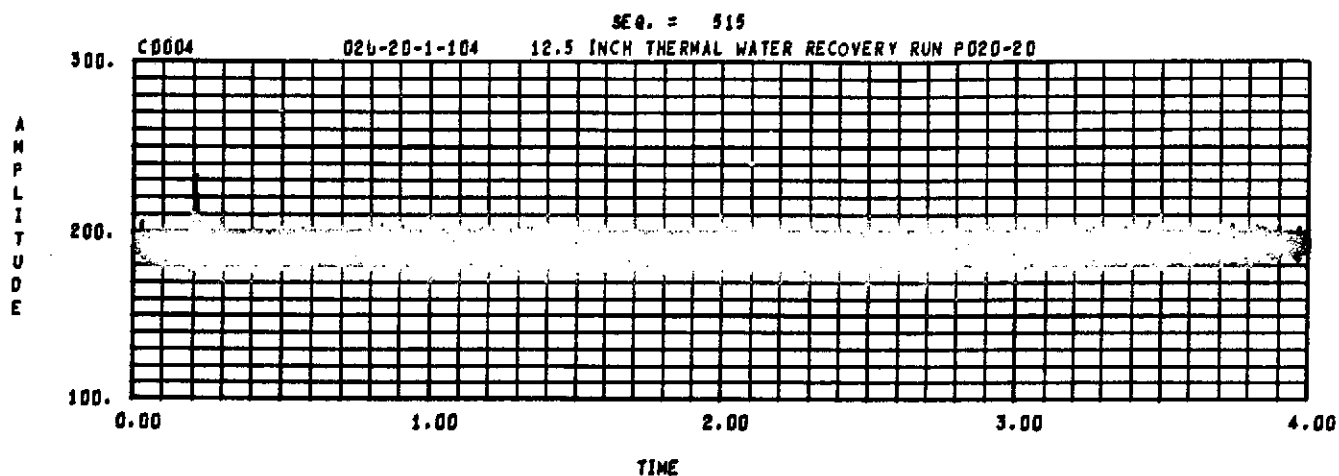




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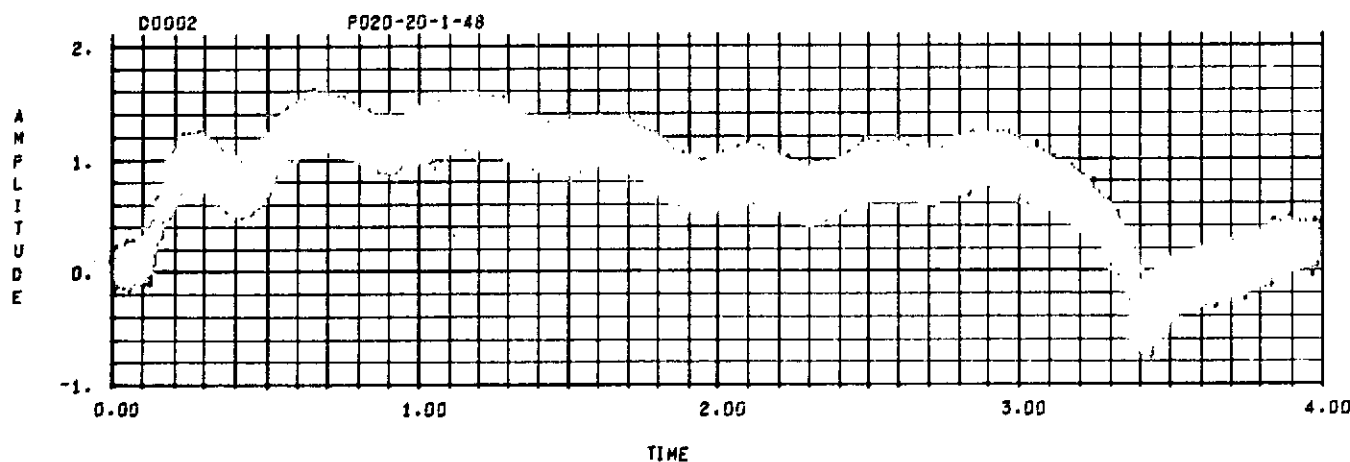
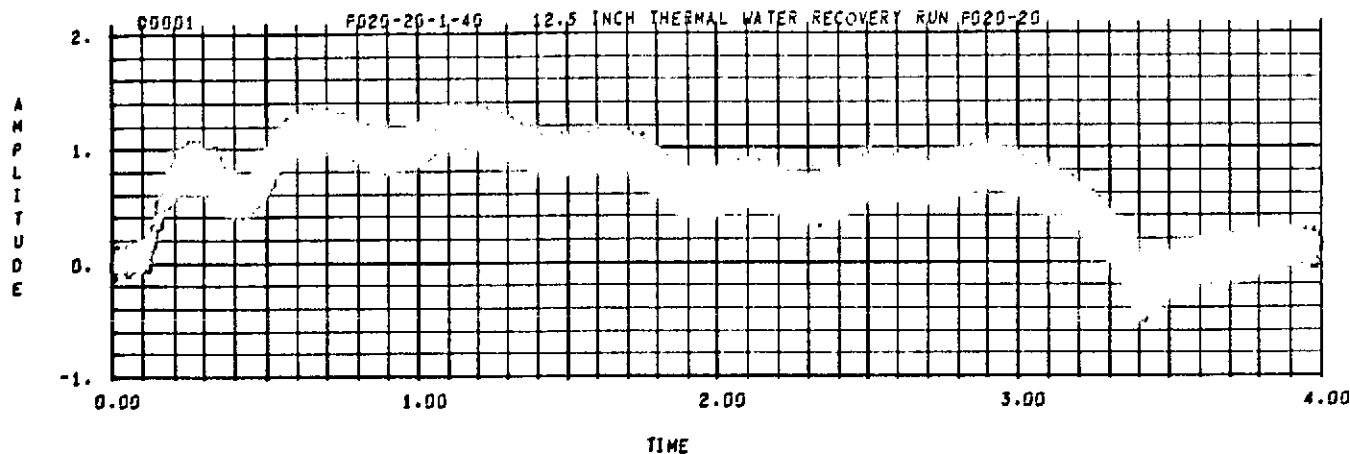
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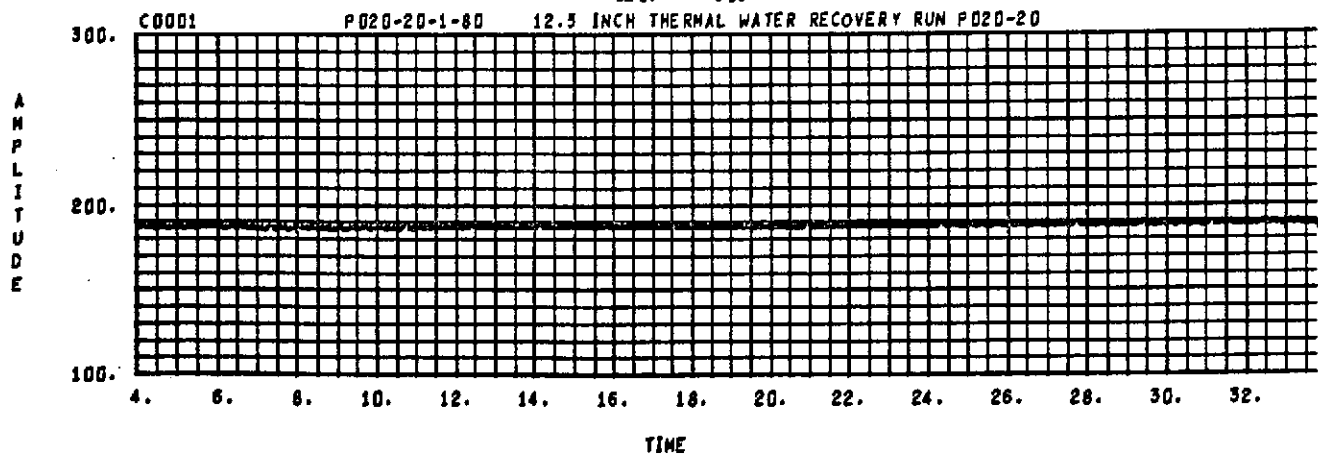
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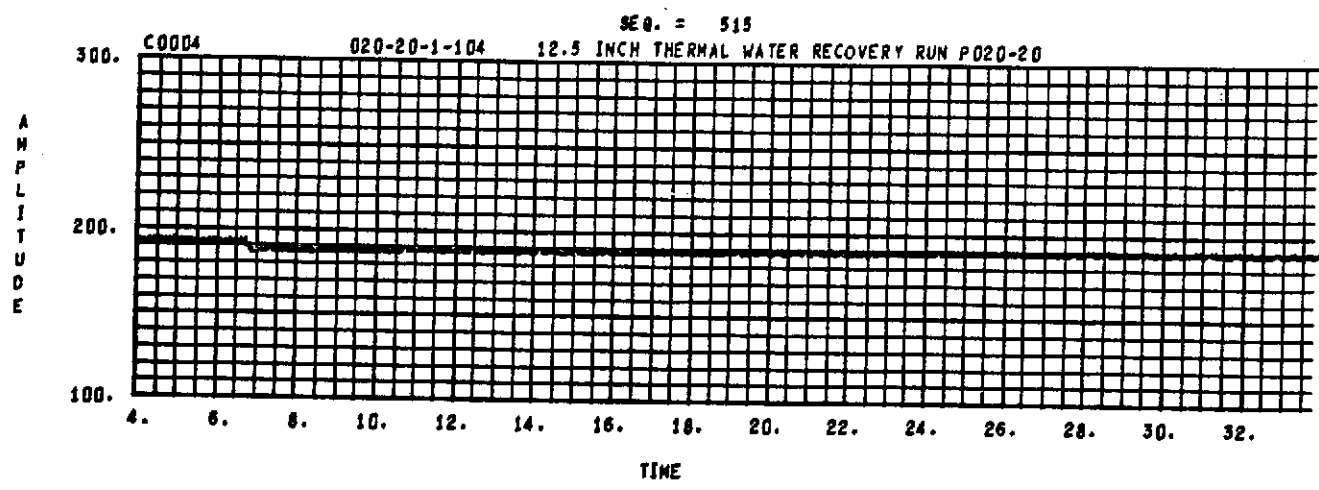
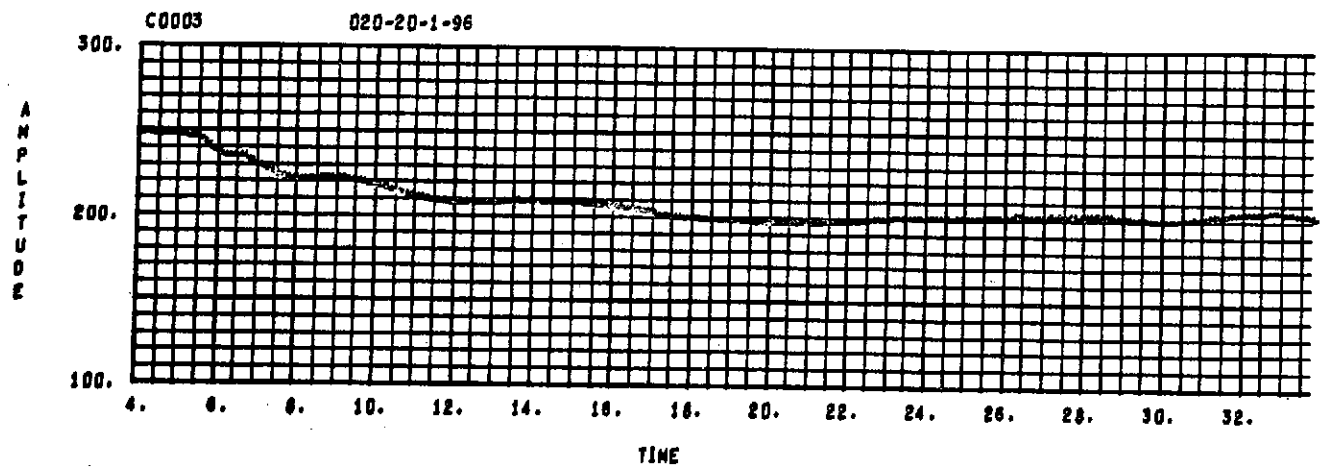
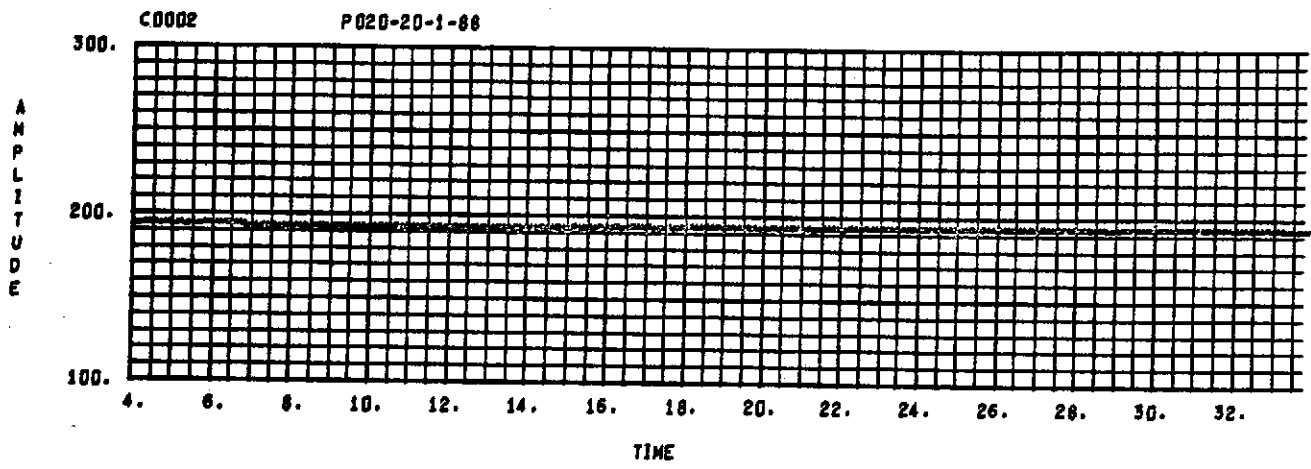
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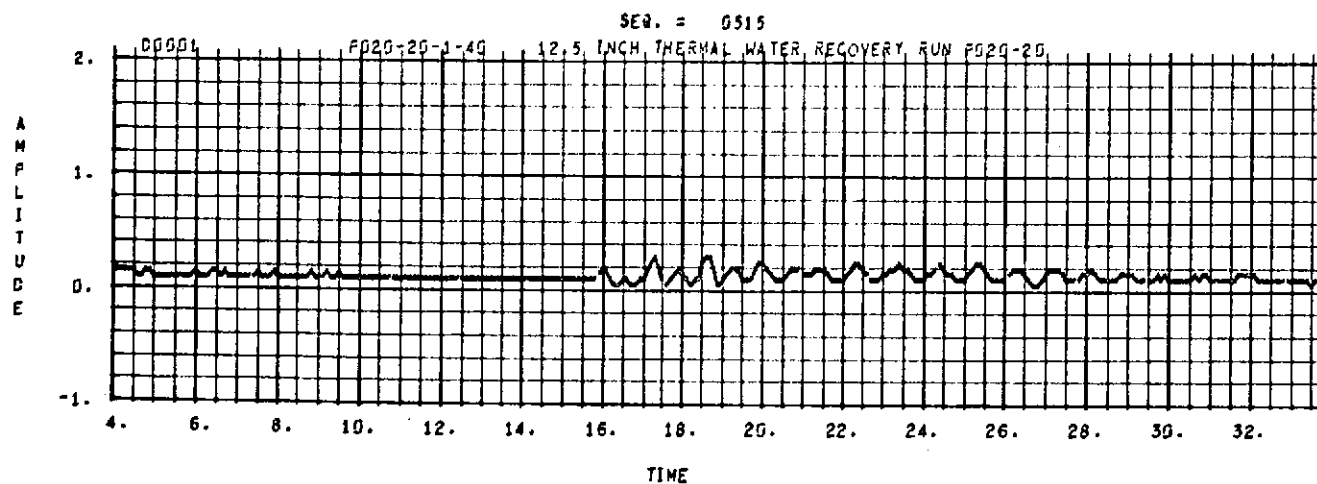
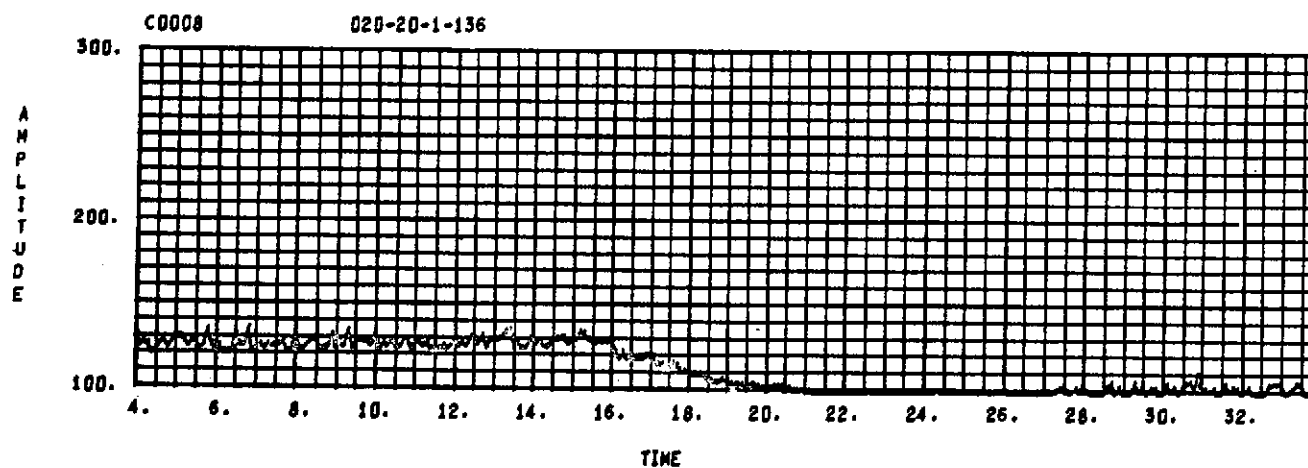
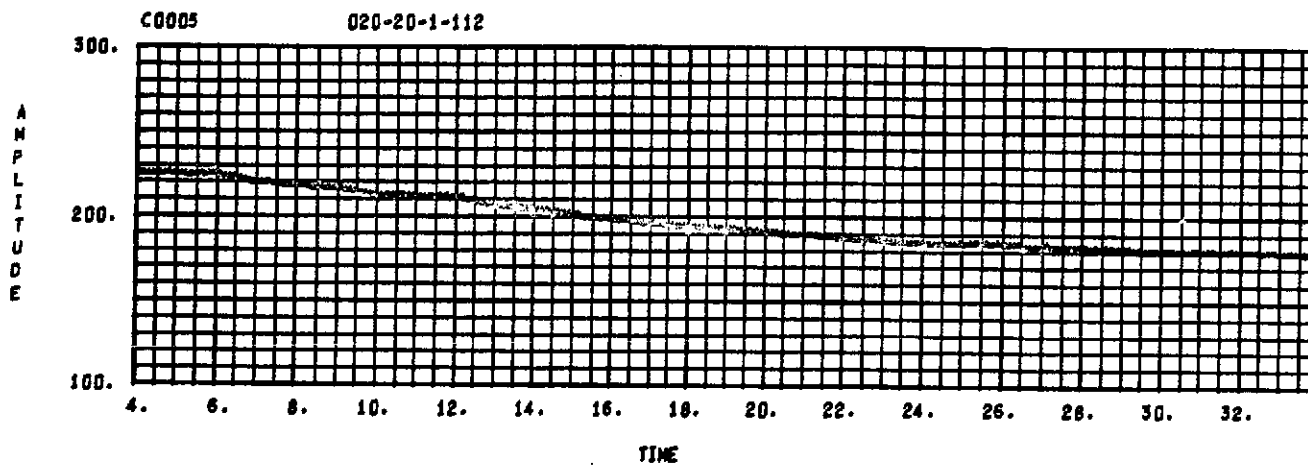


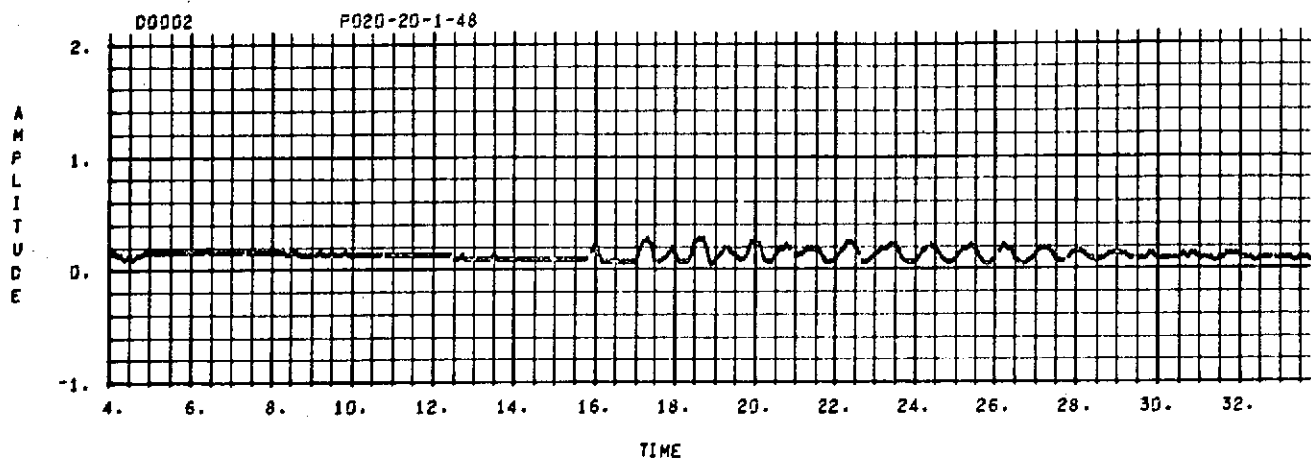
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11



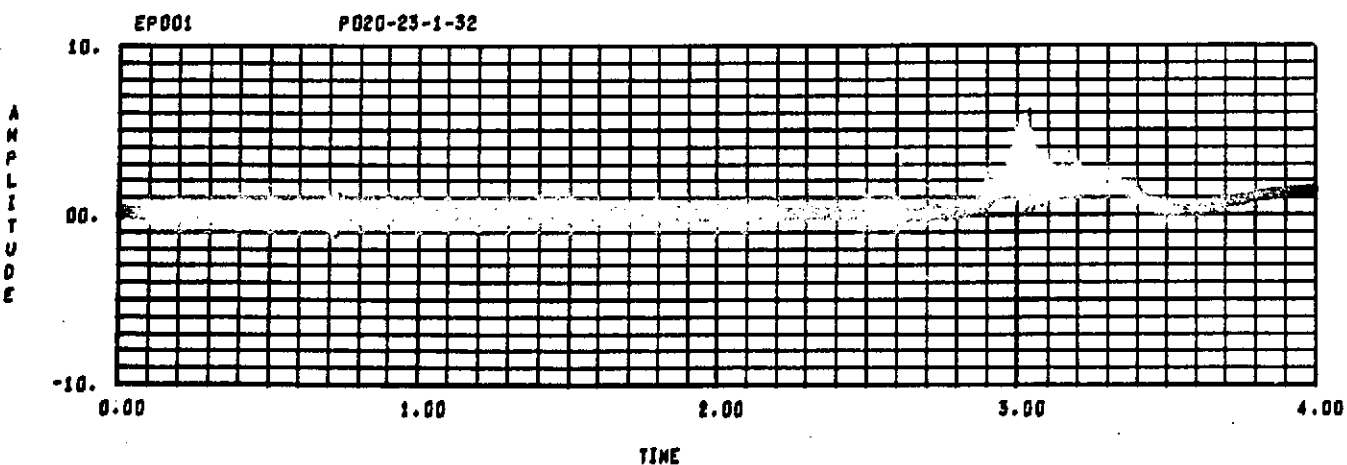
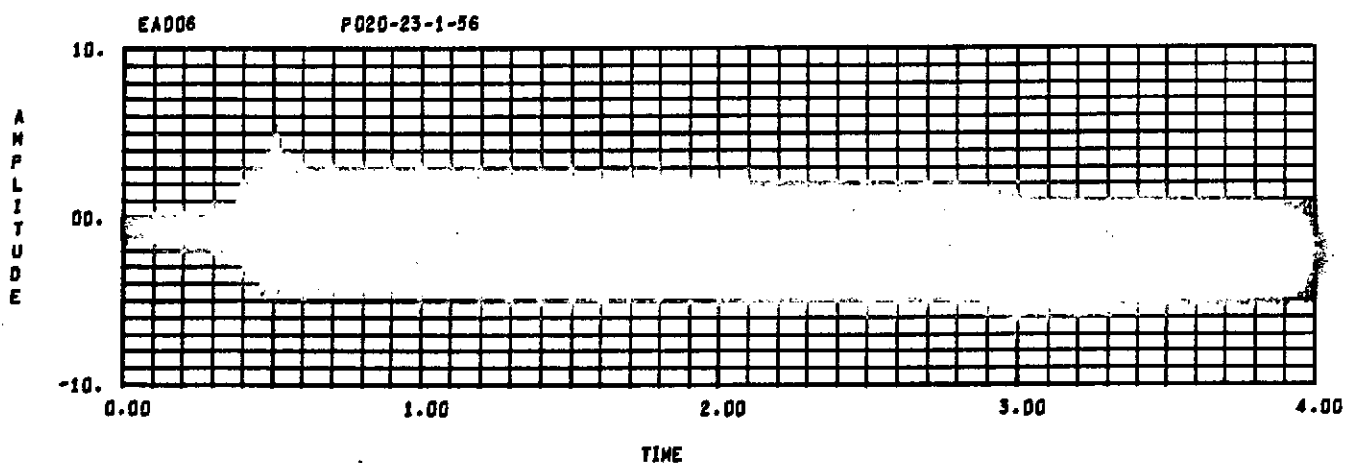
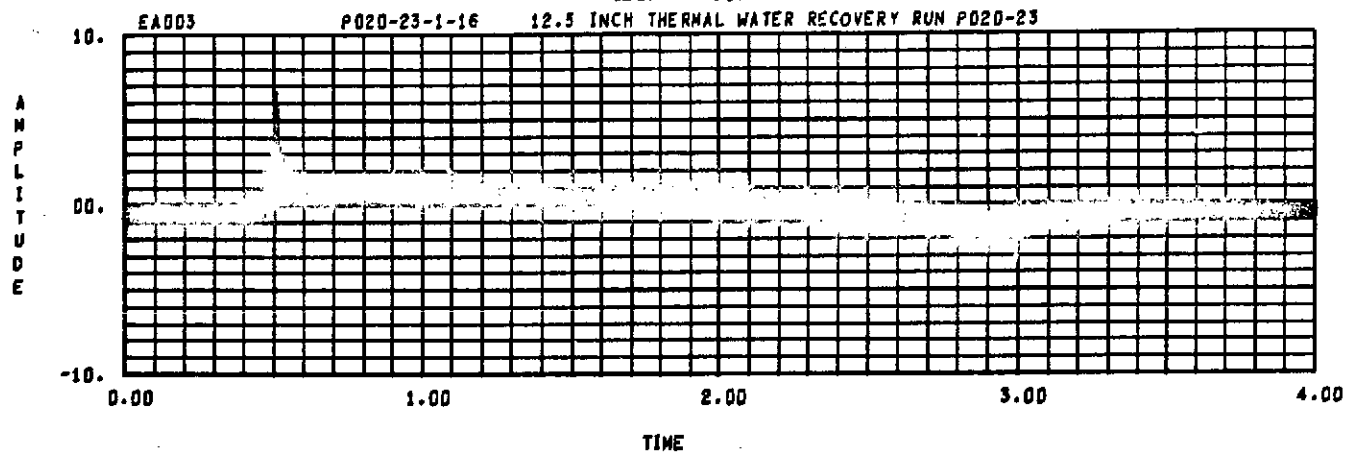


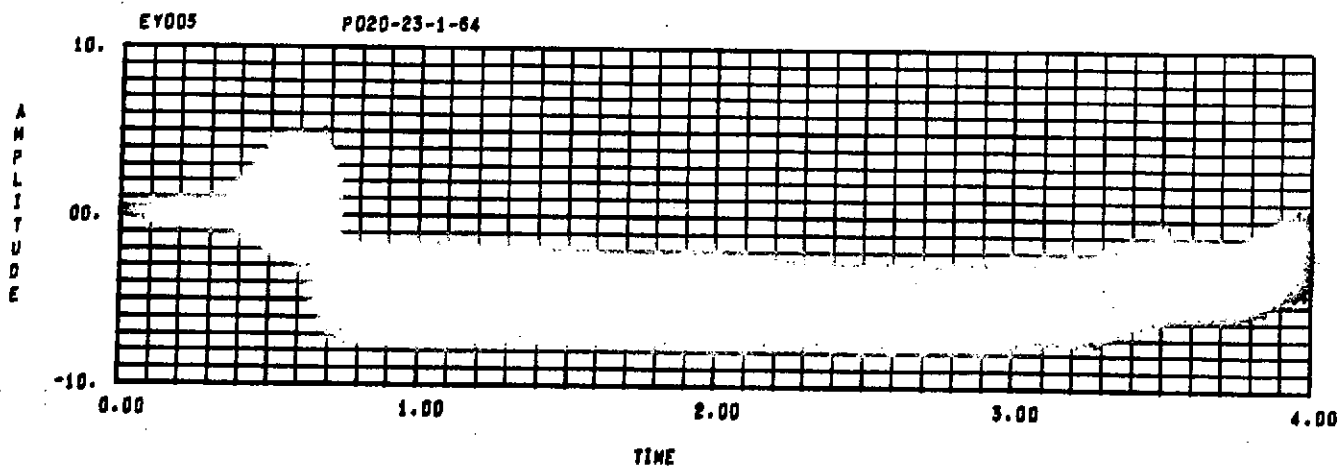
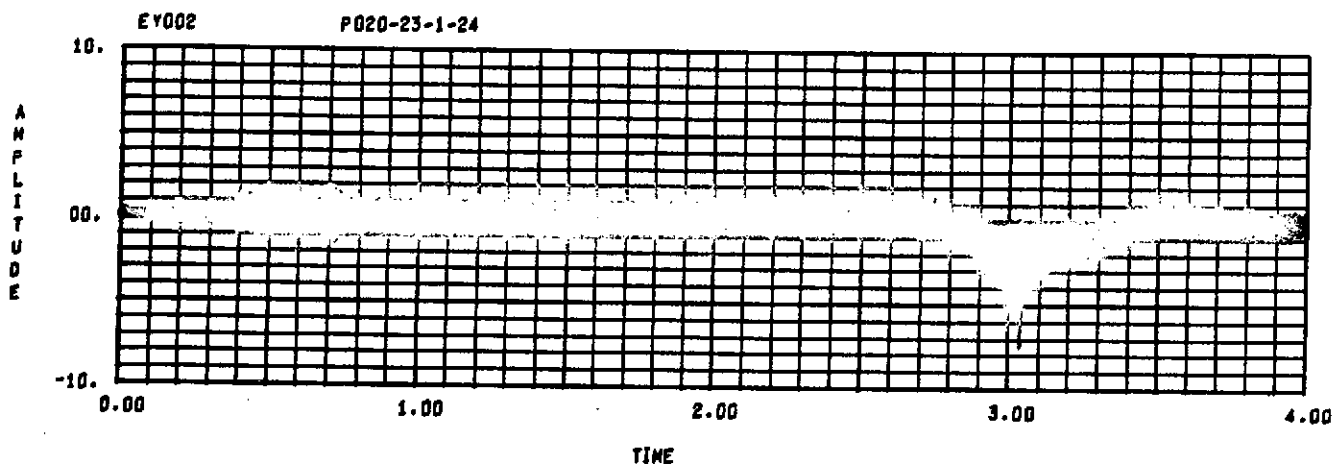
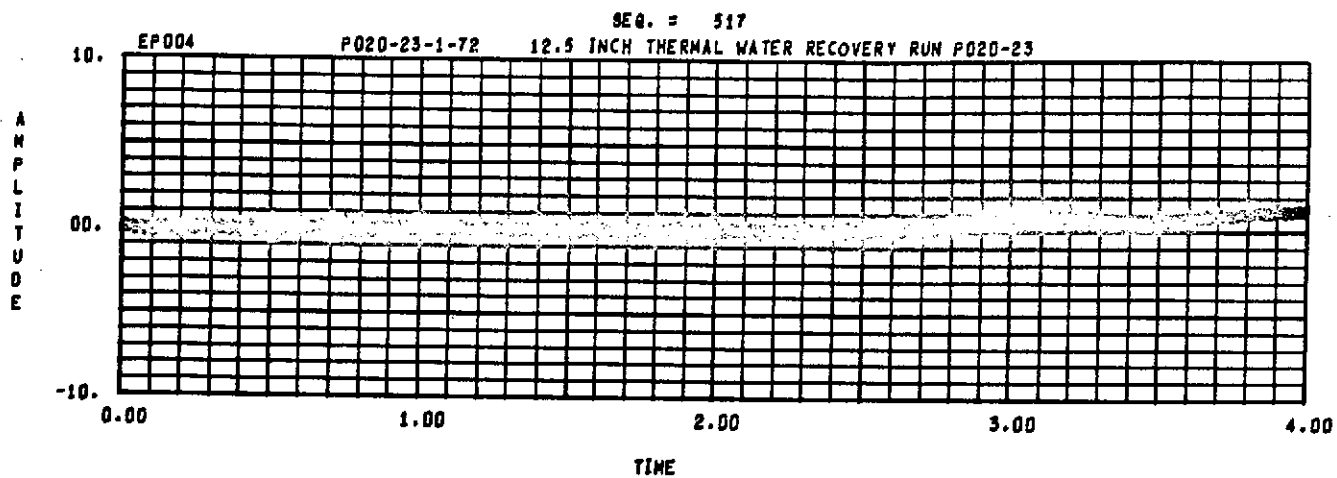




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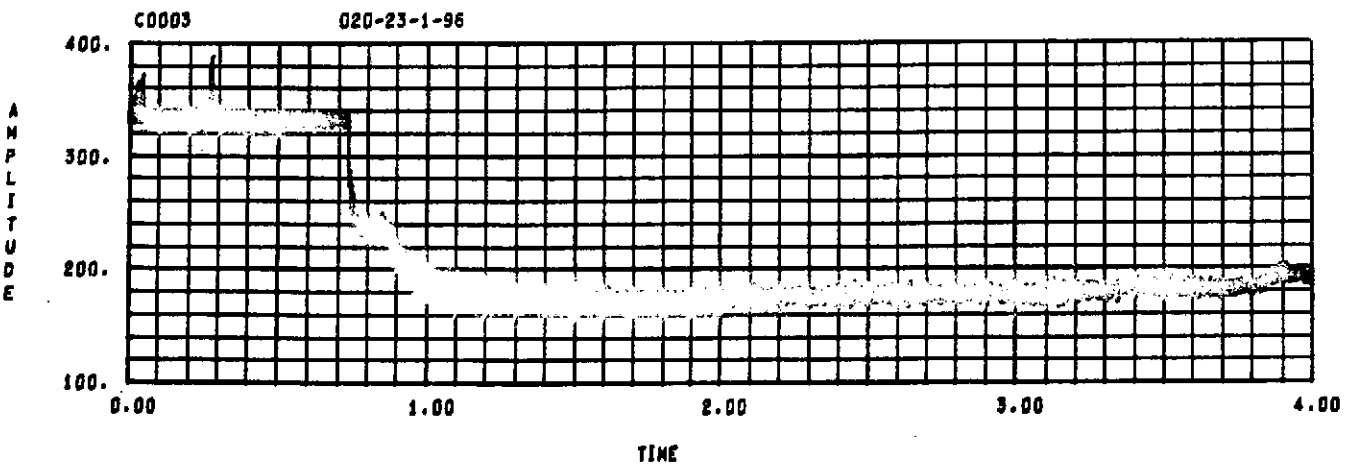
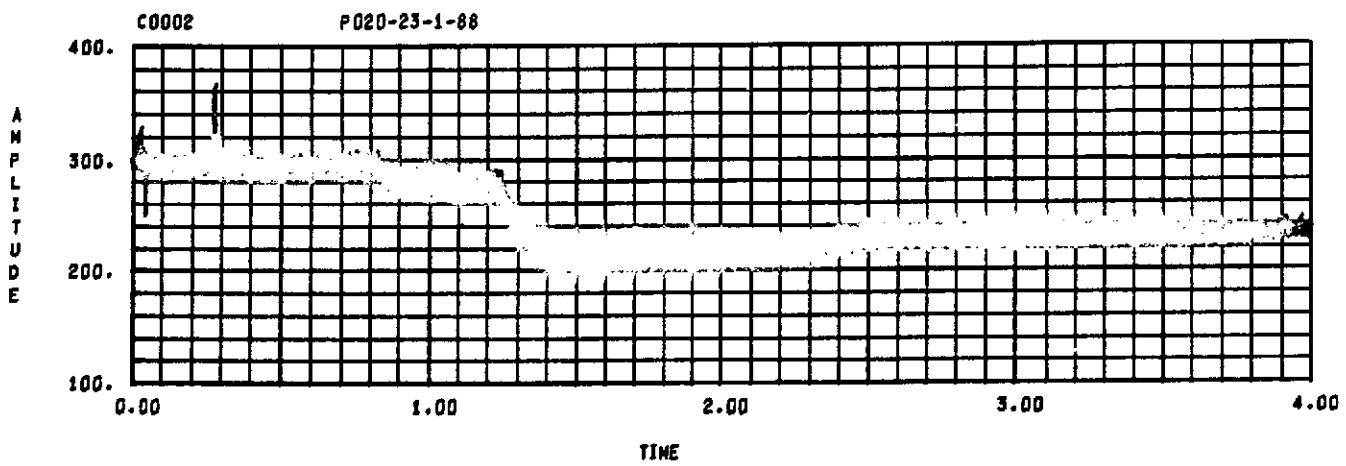
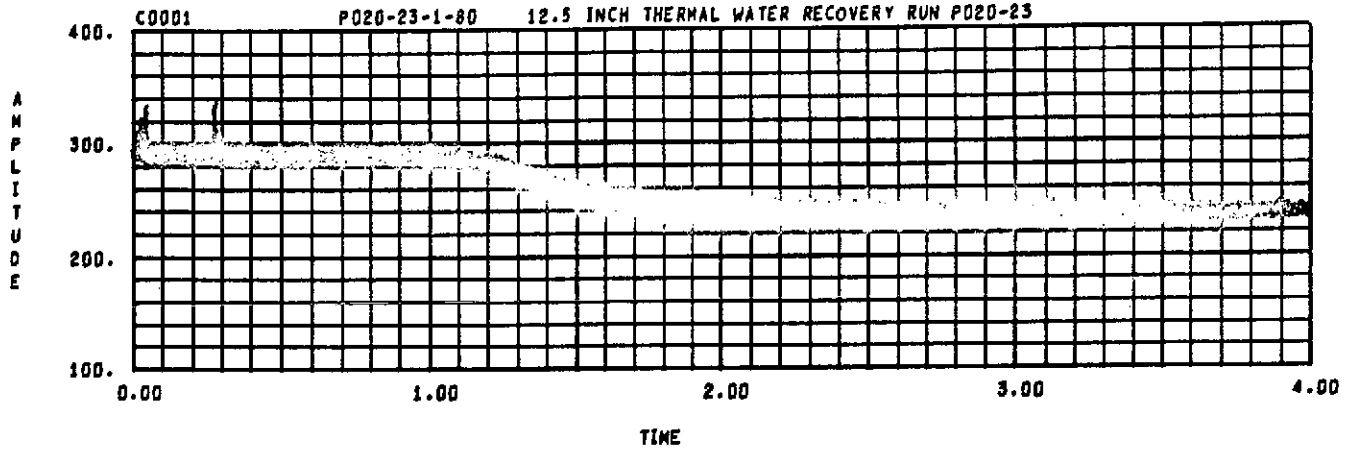
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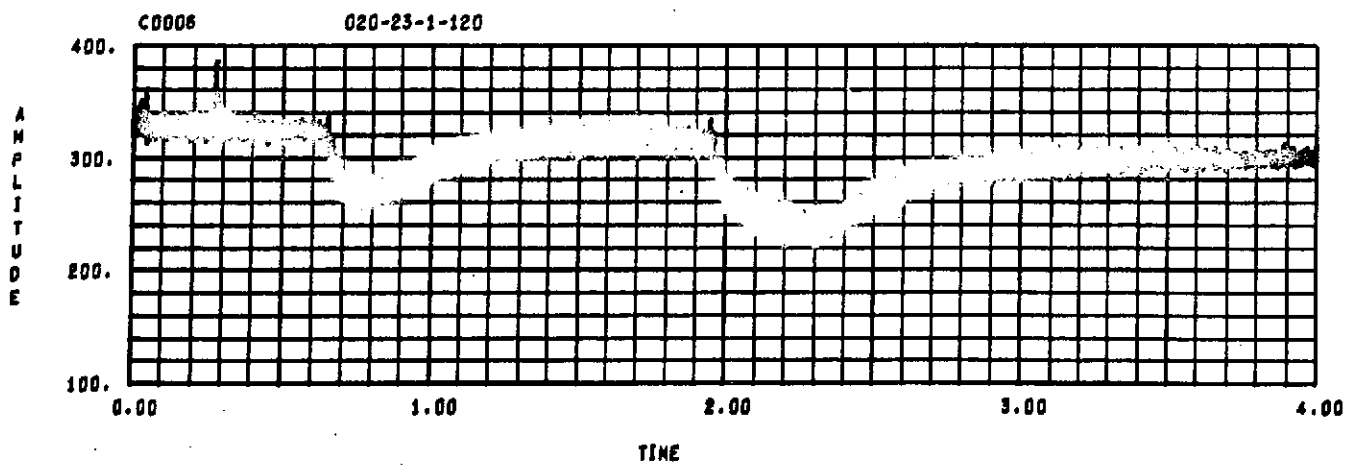
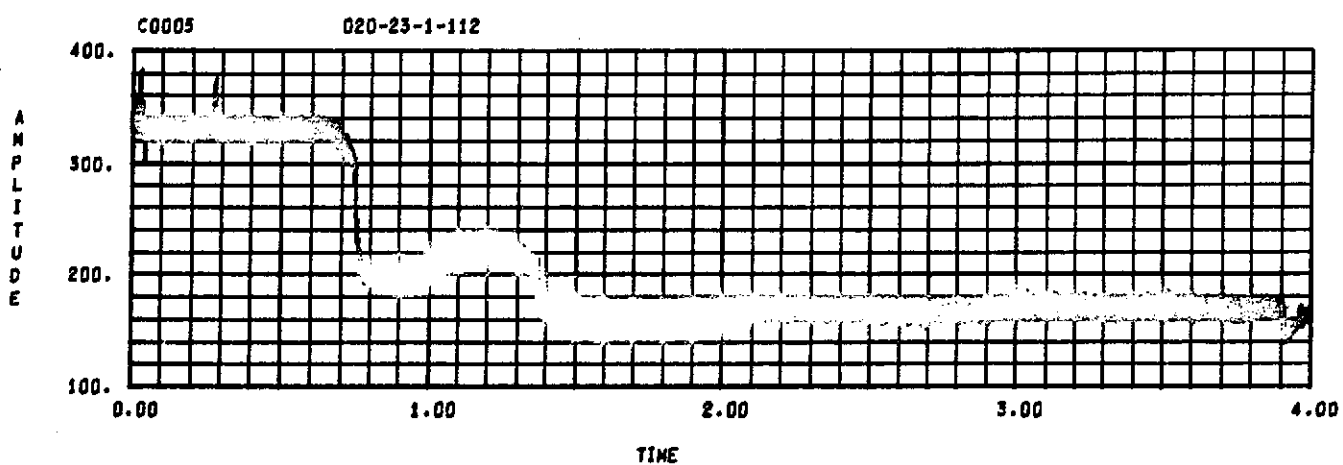
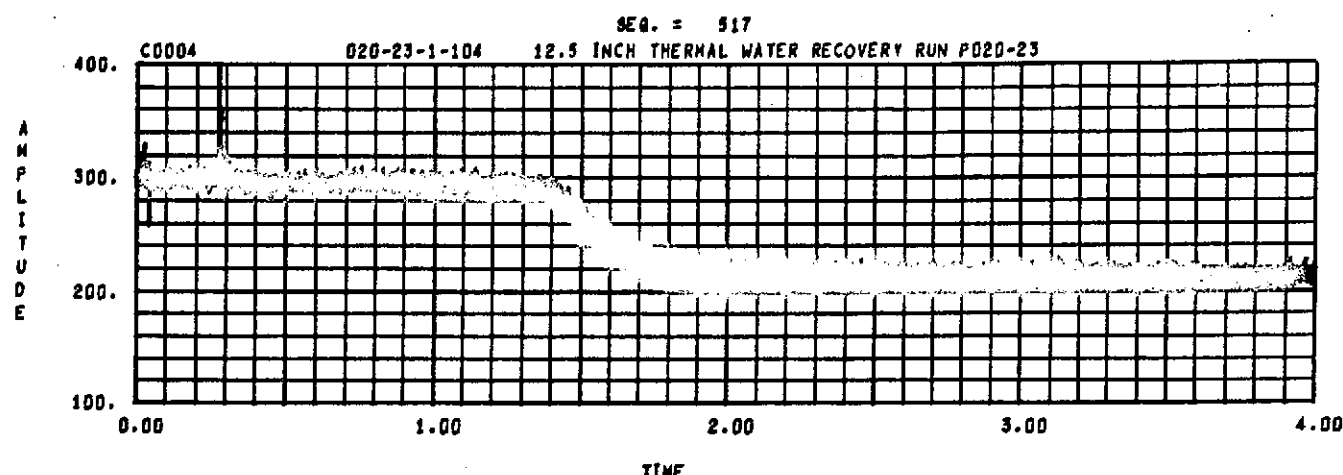


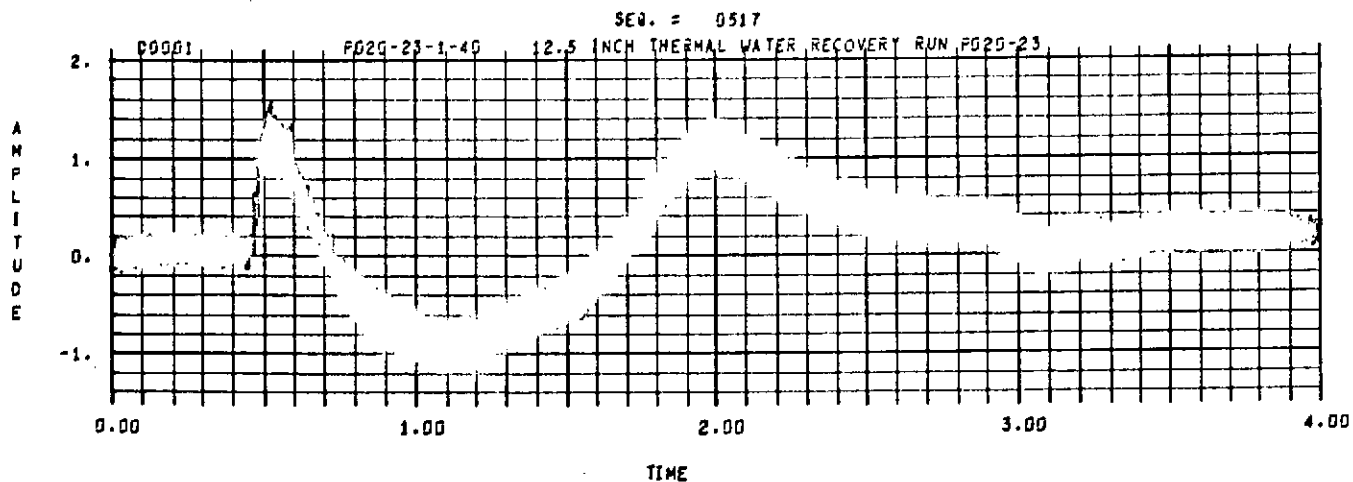
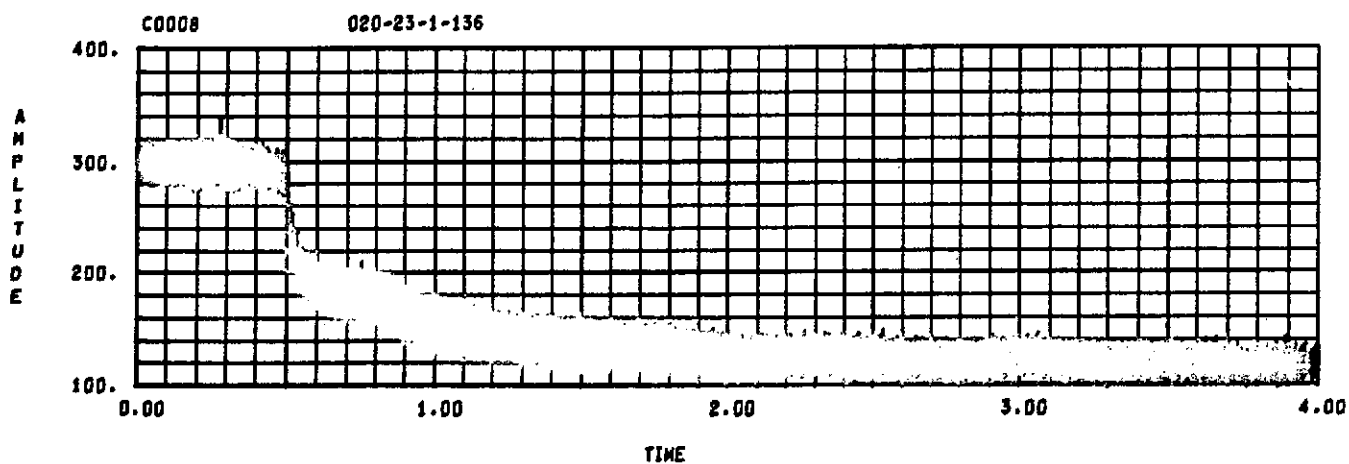
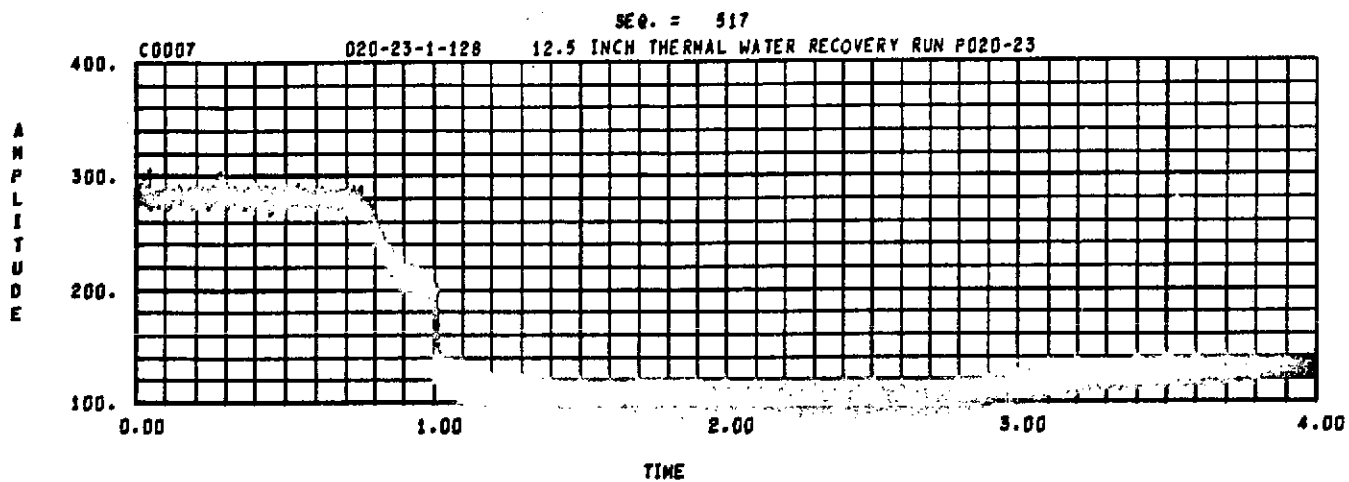


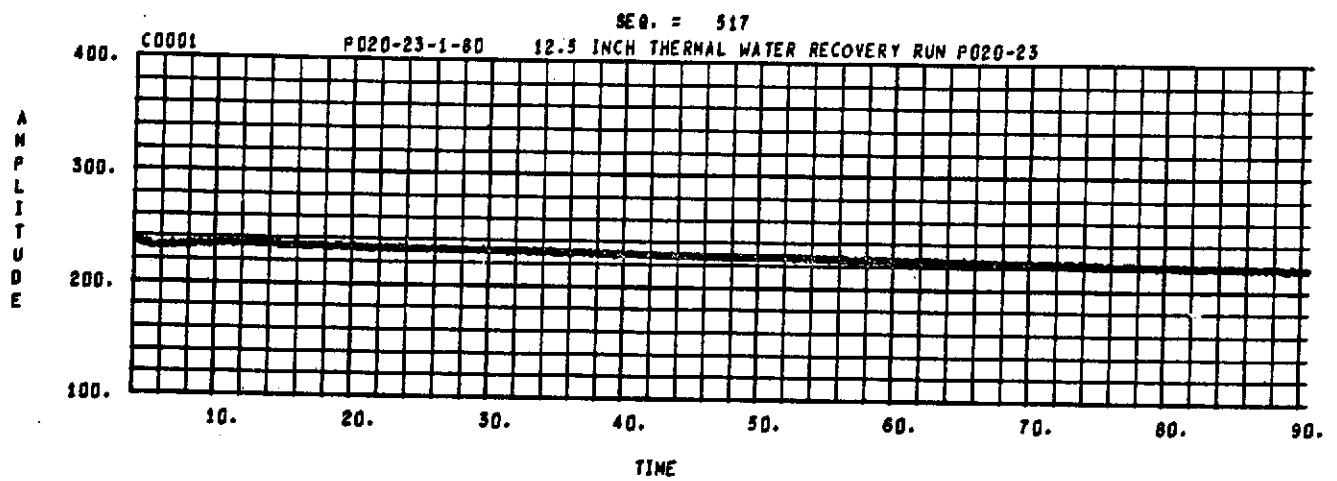
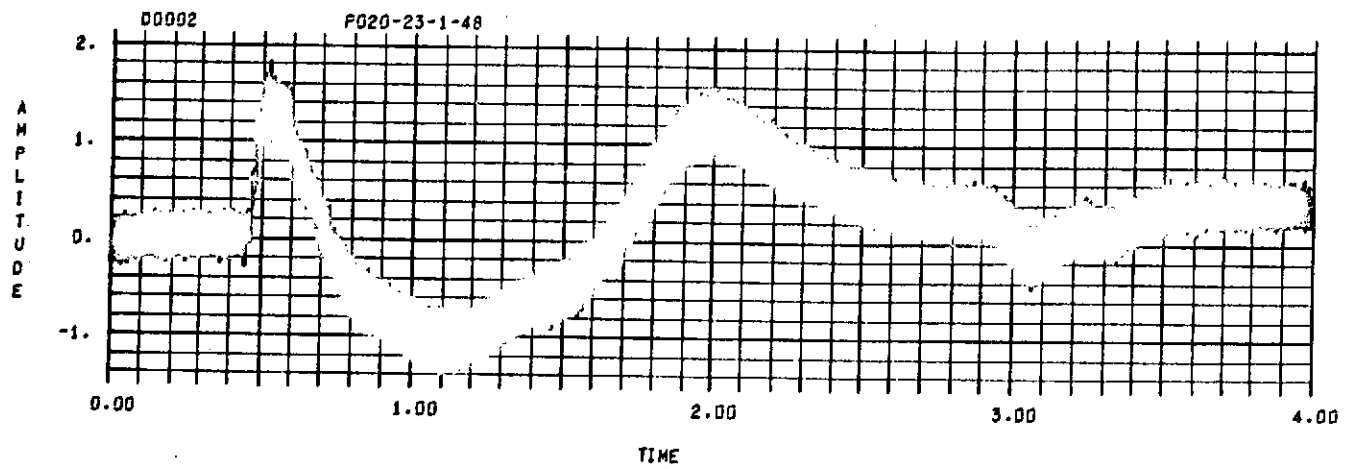
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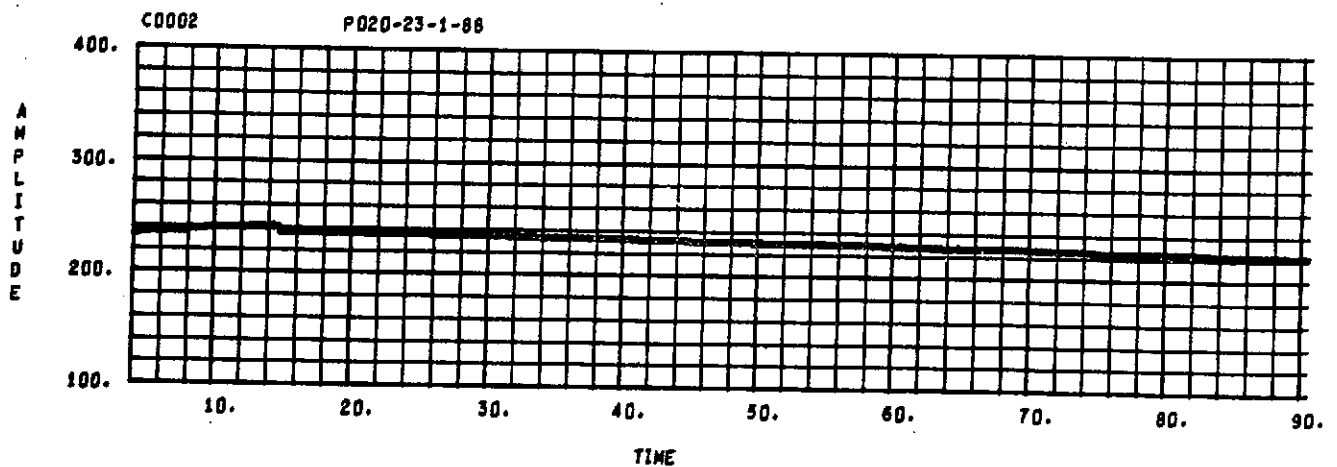


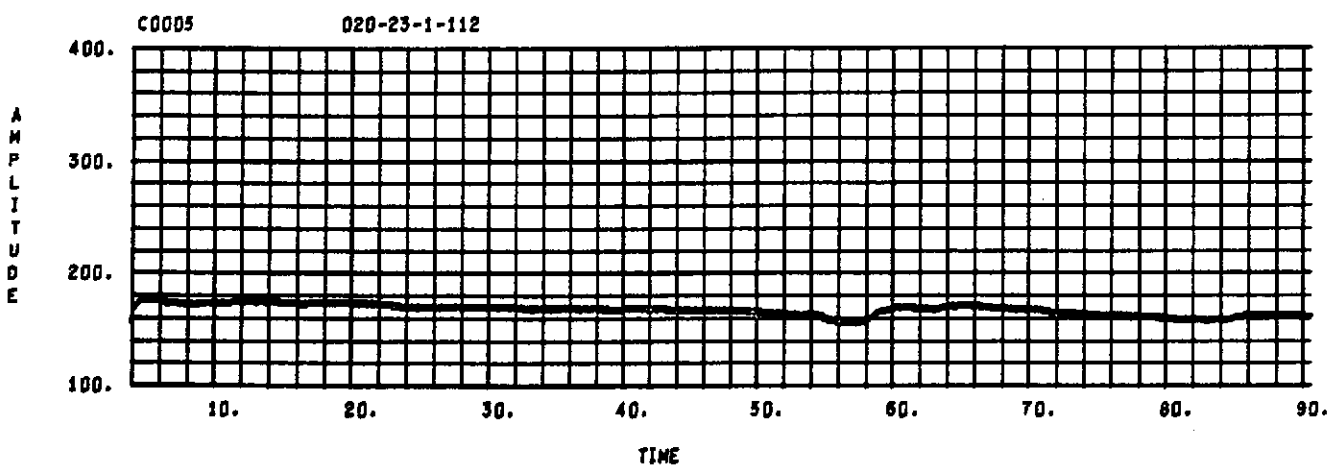
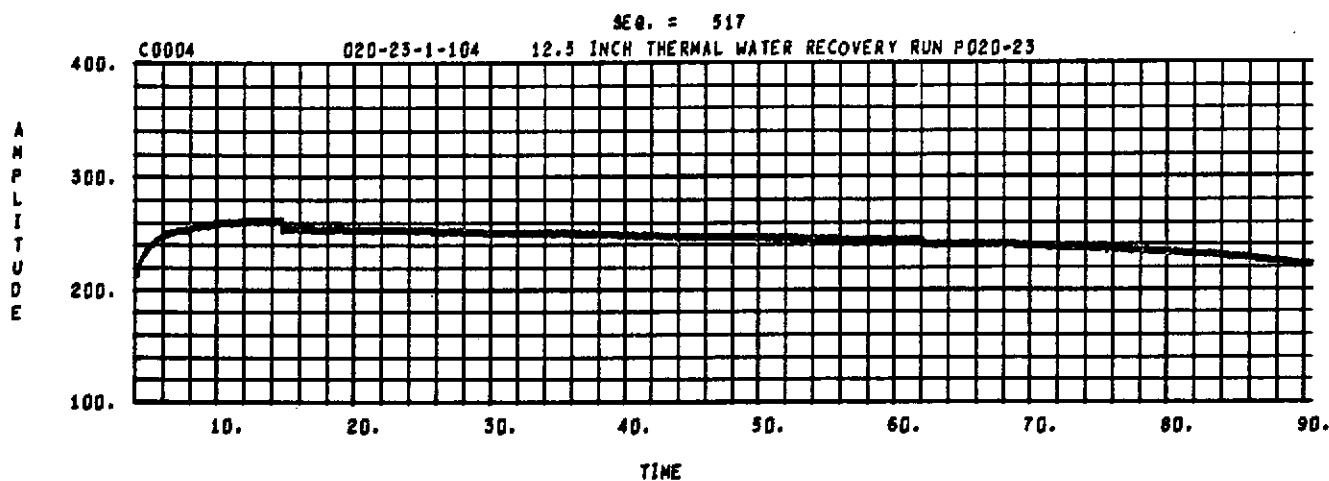
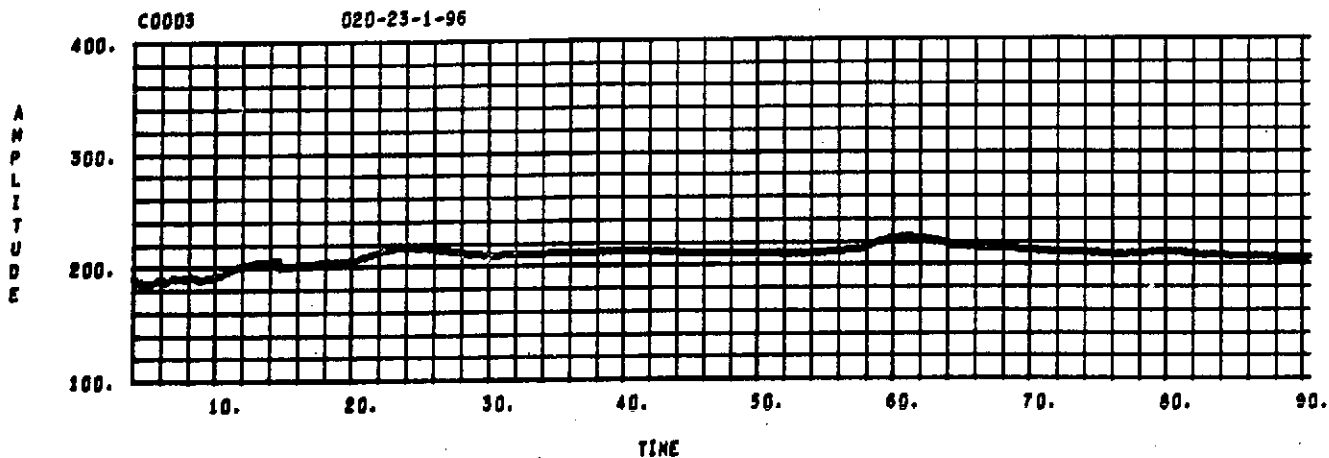


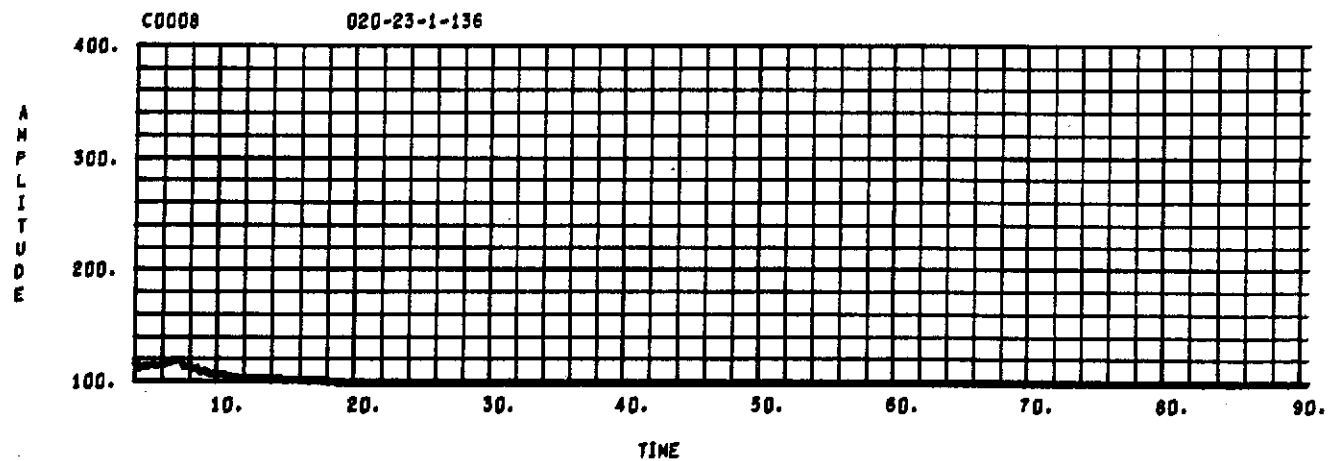
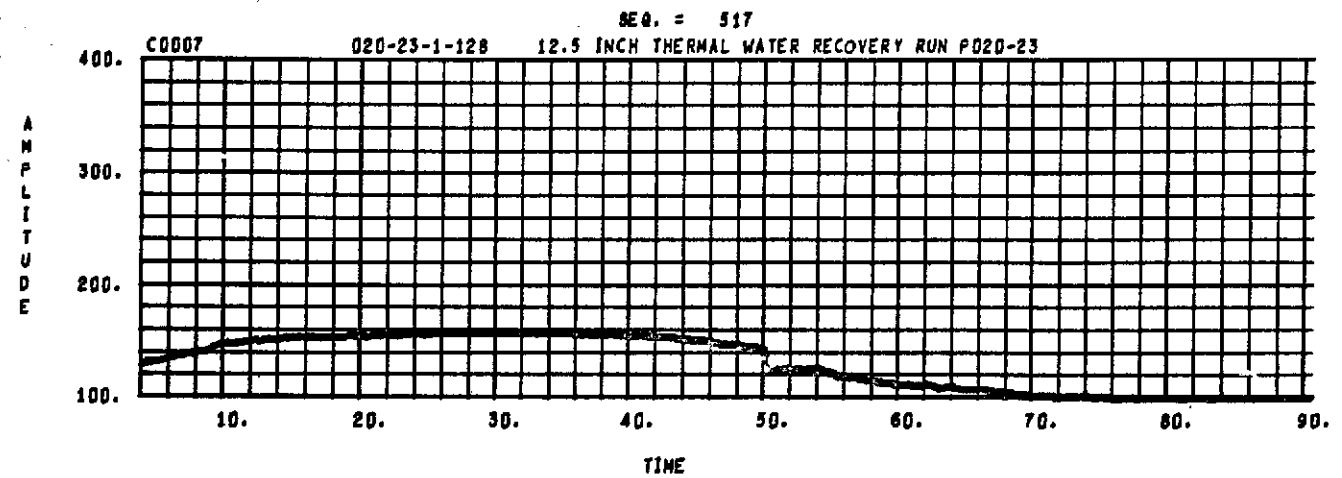
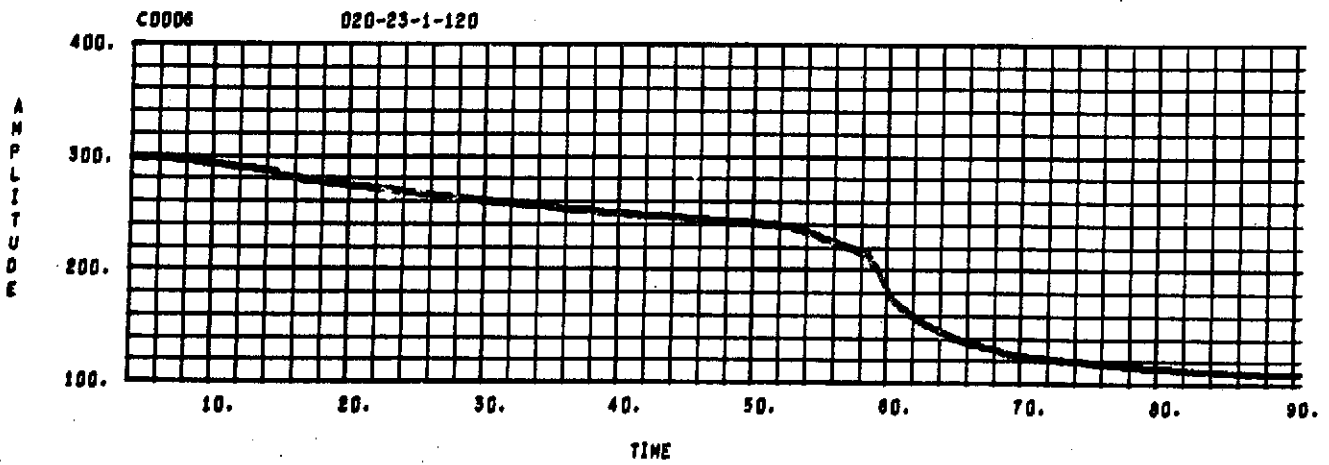




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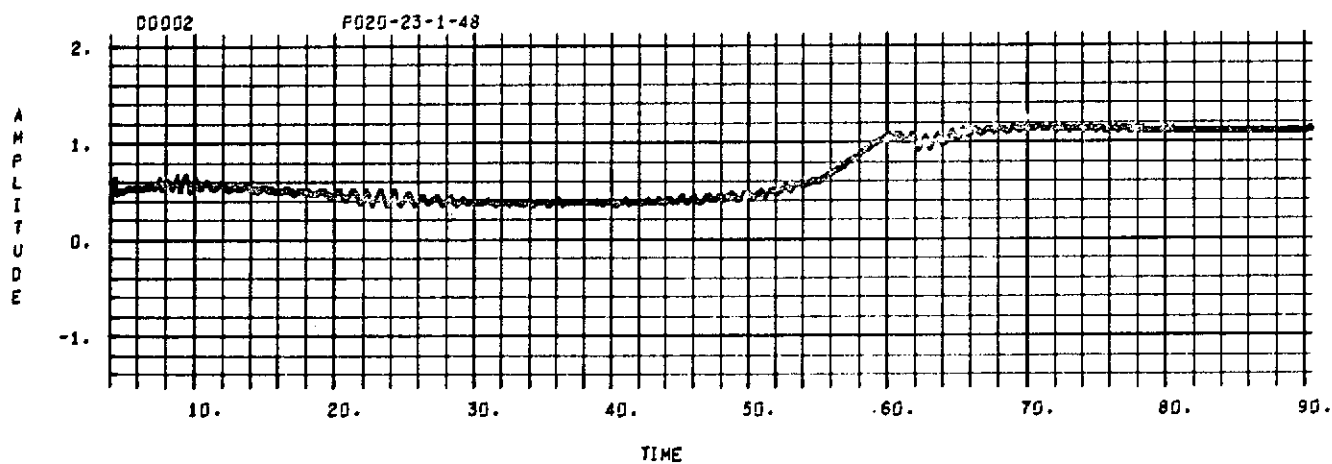
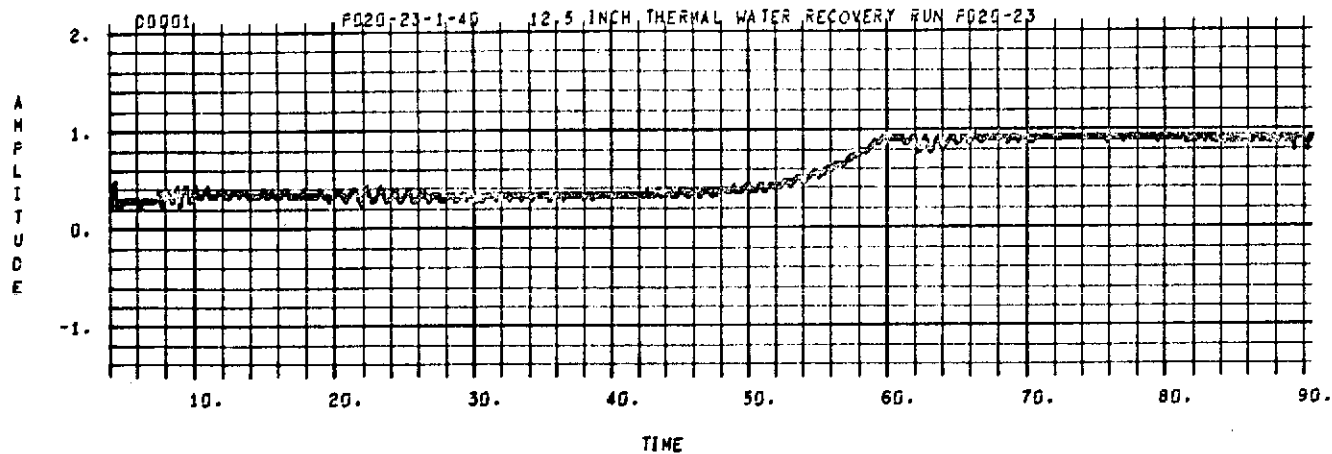




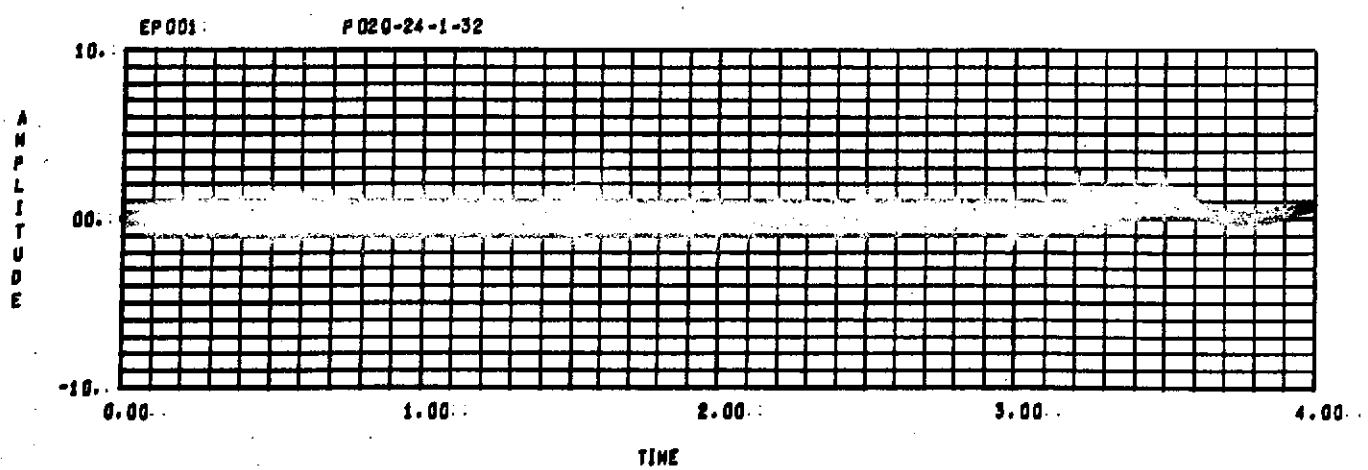
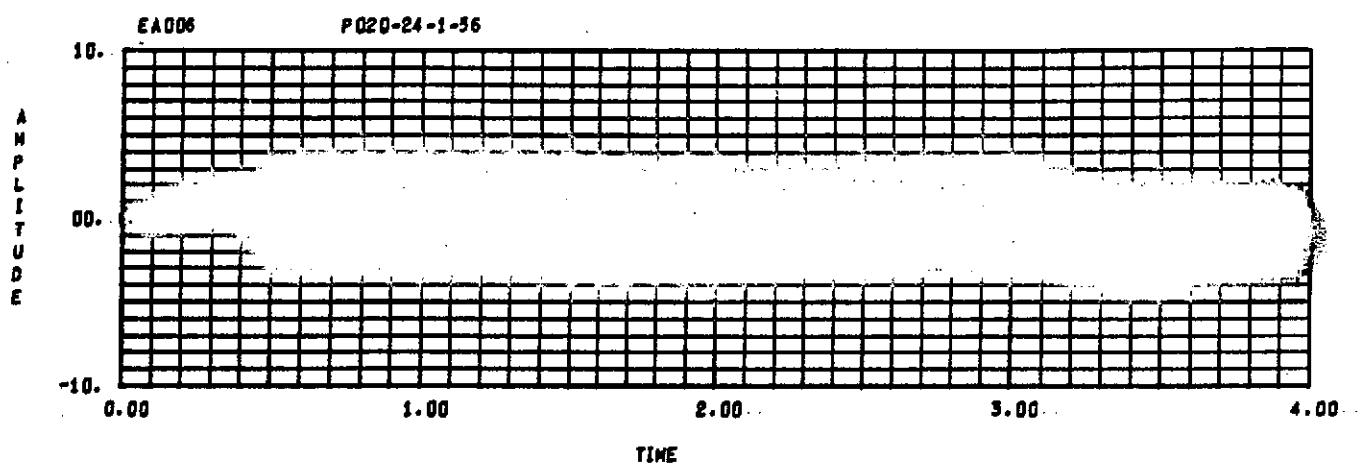
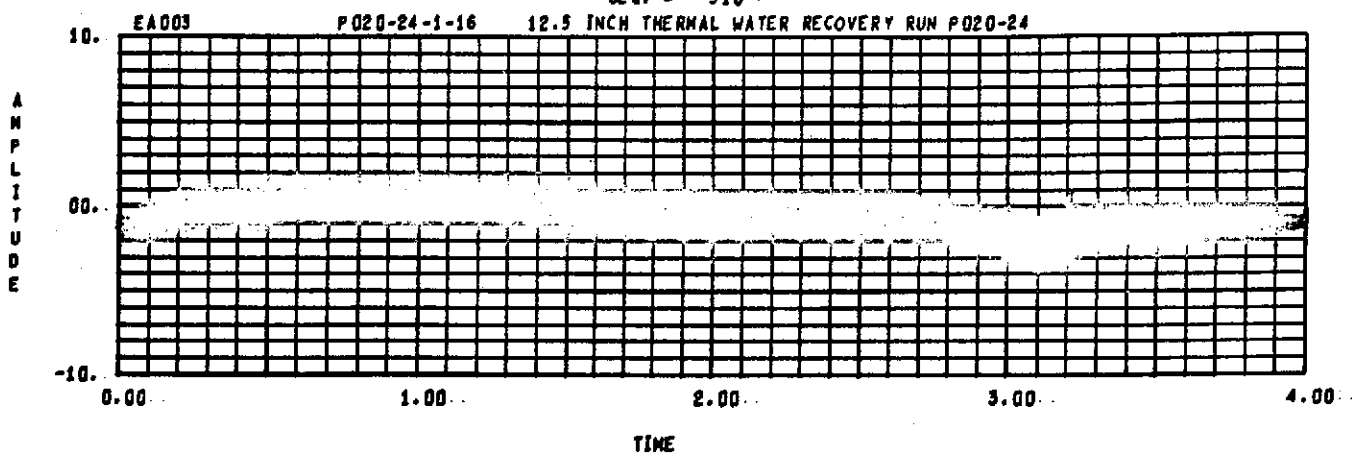


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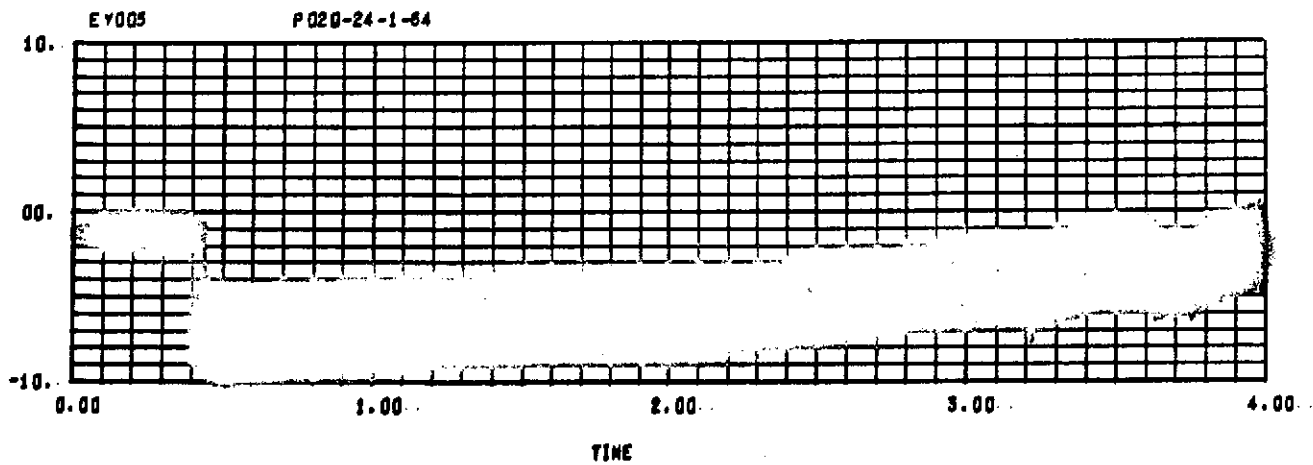
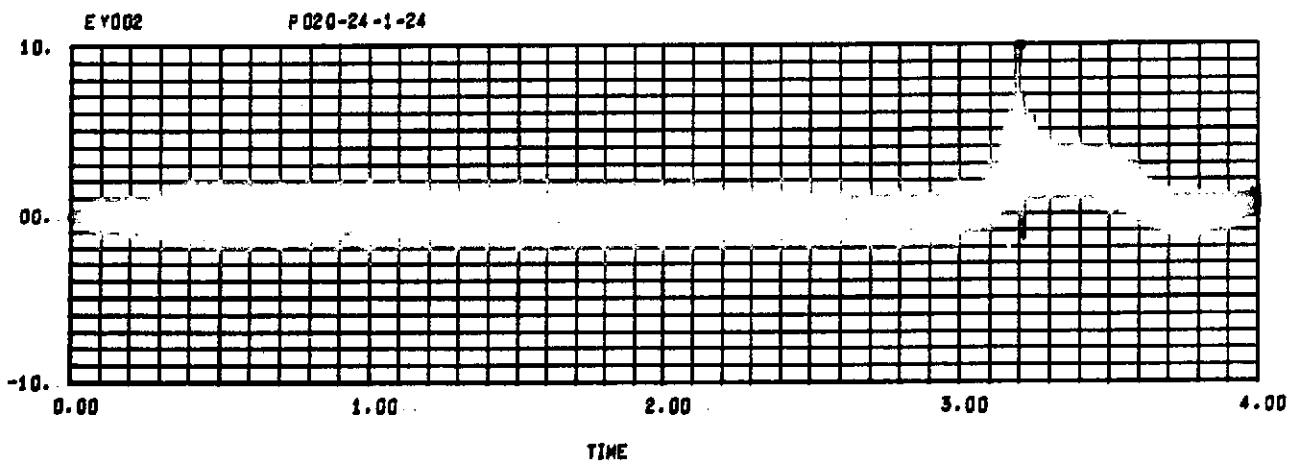
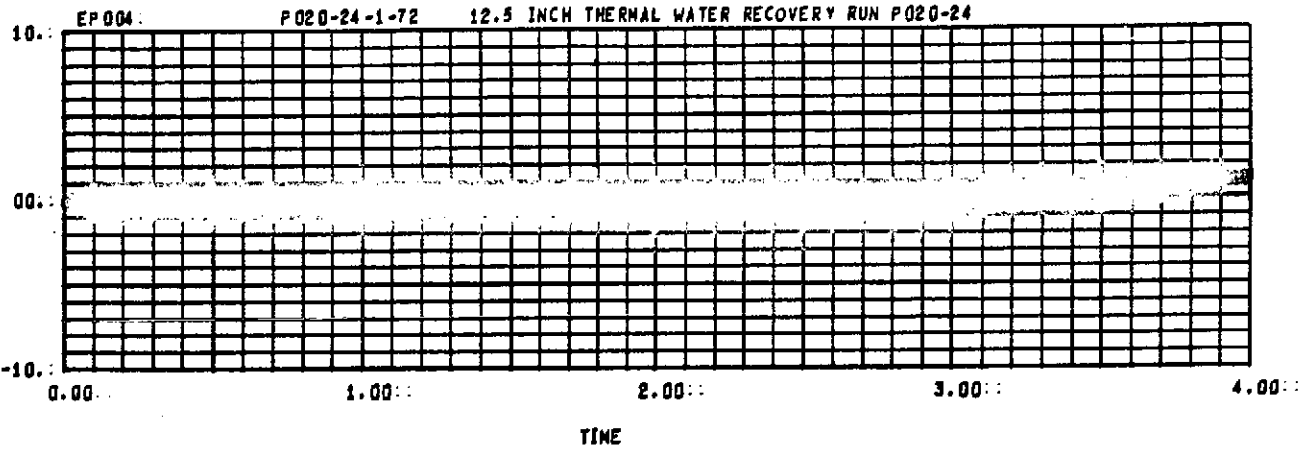


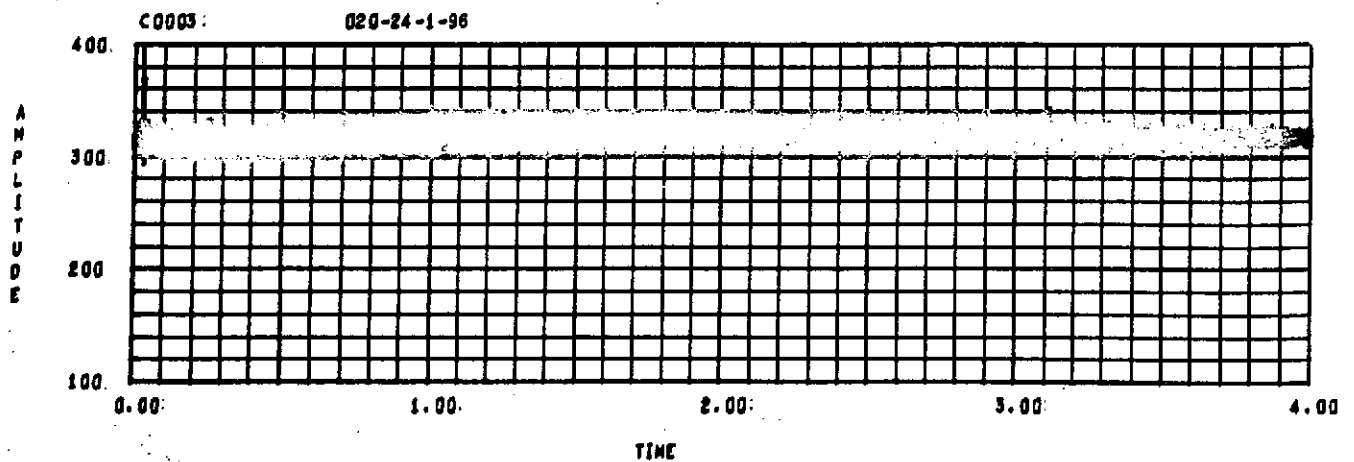
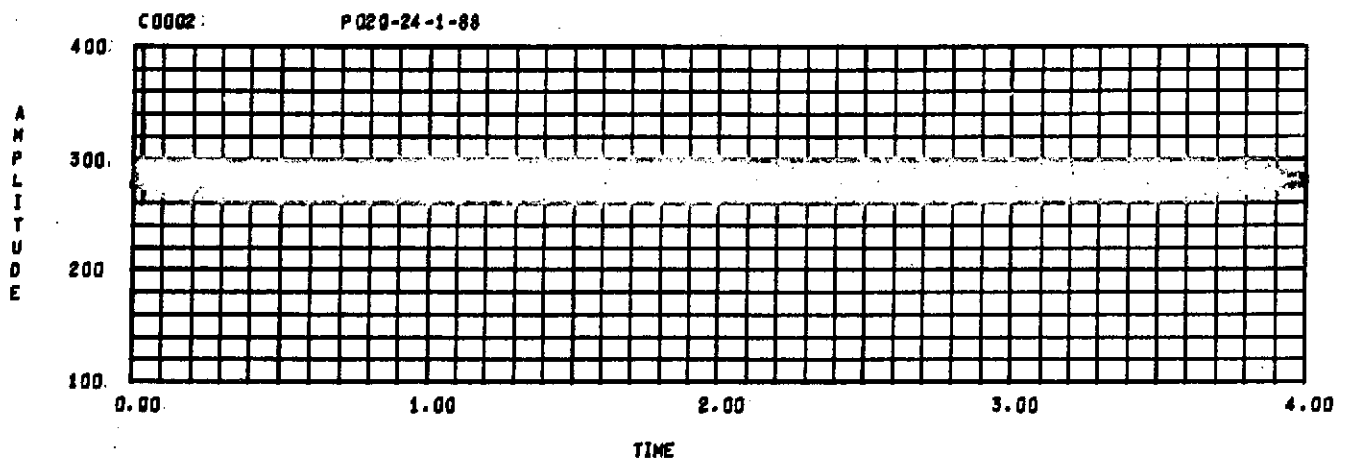
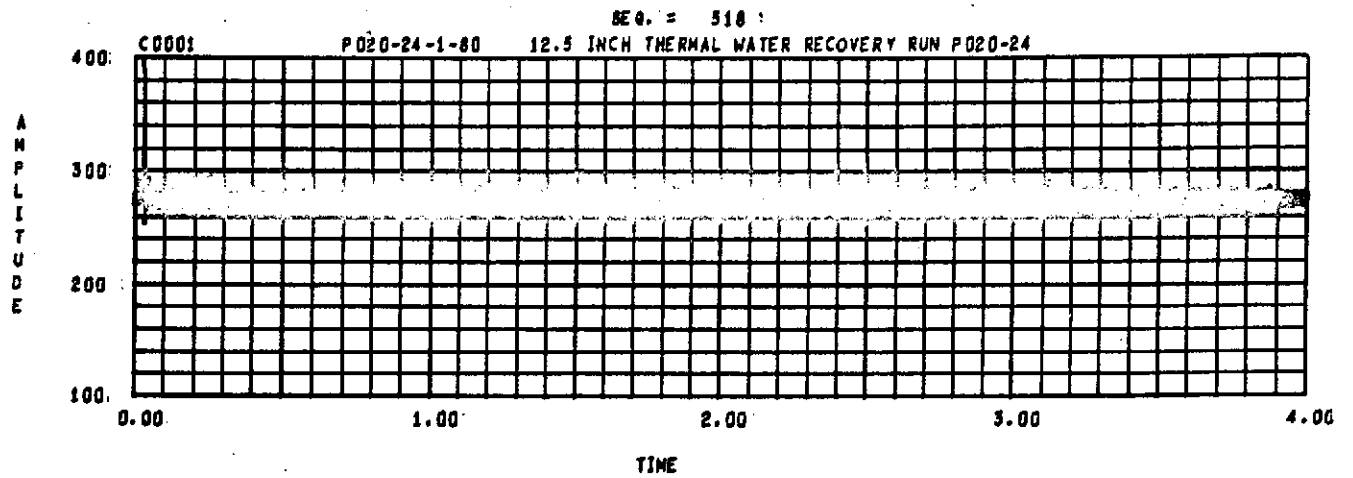
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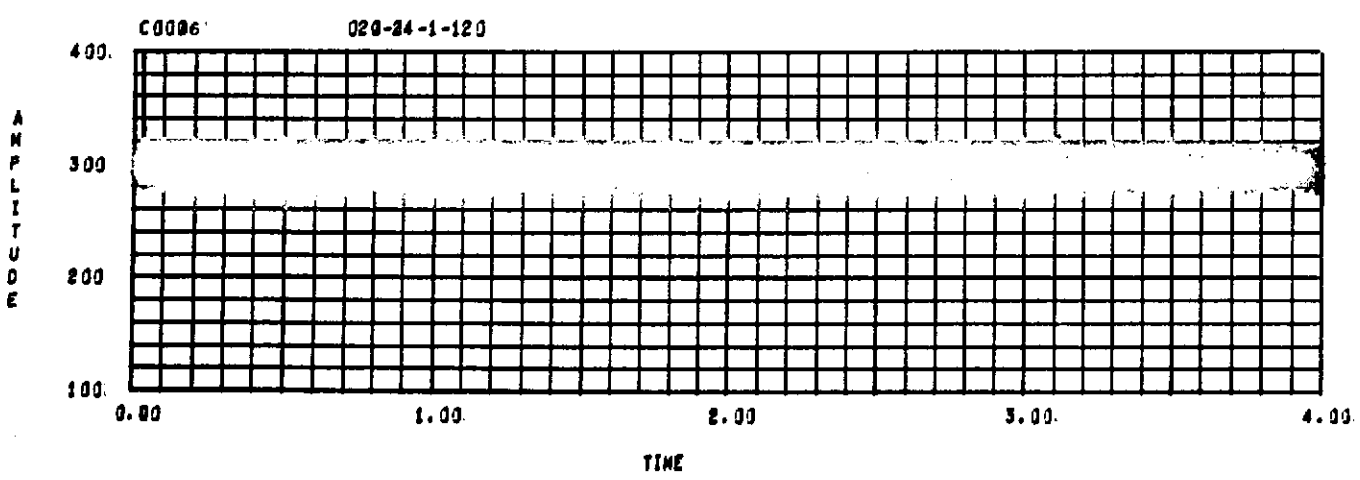
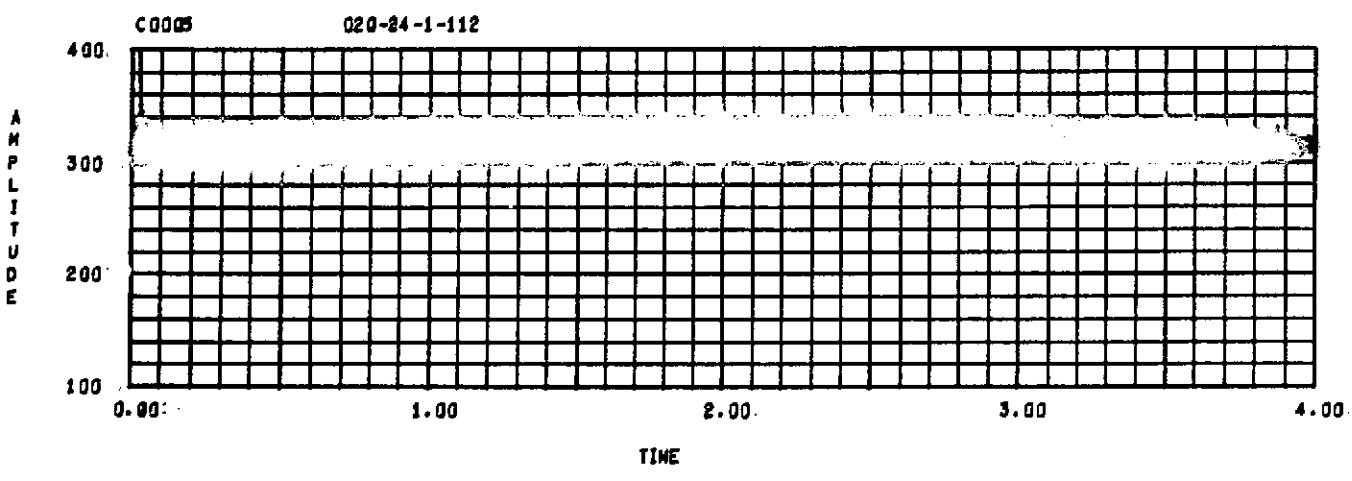
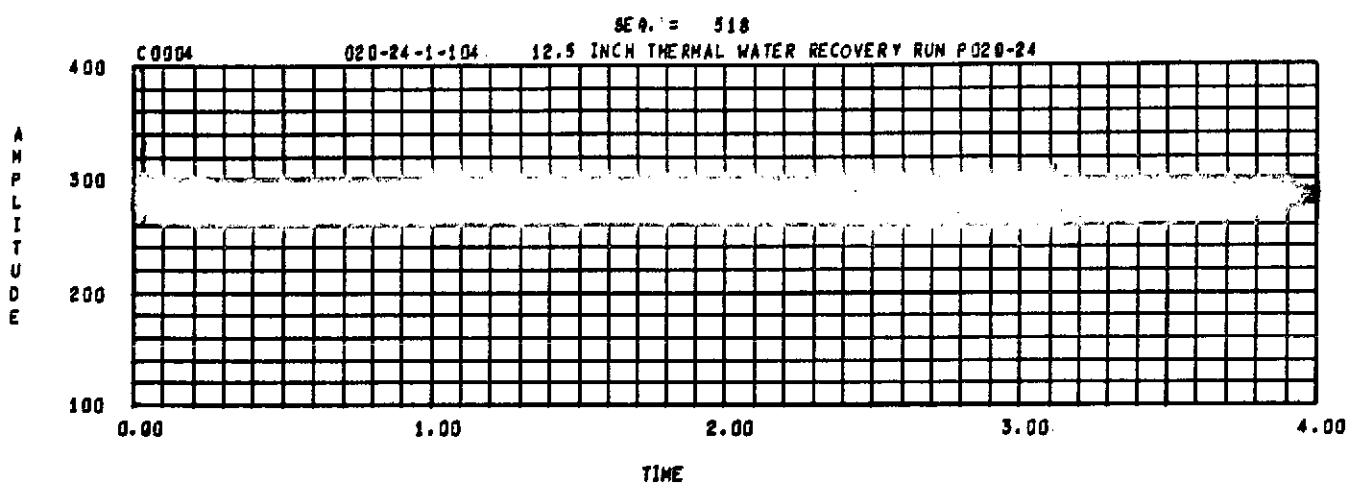


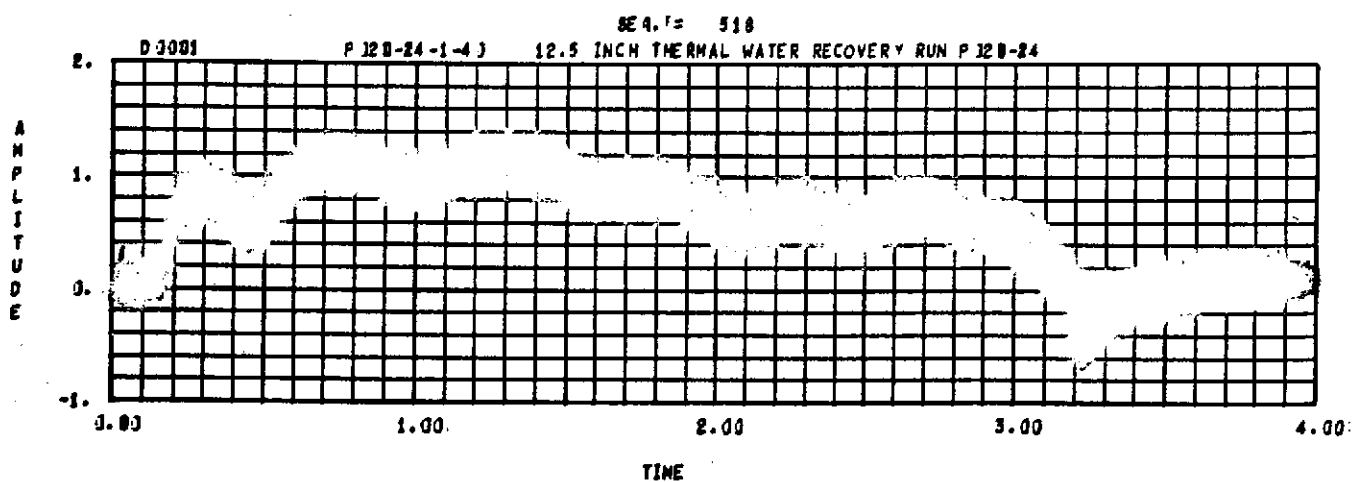
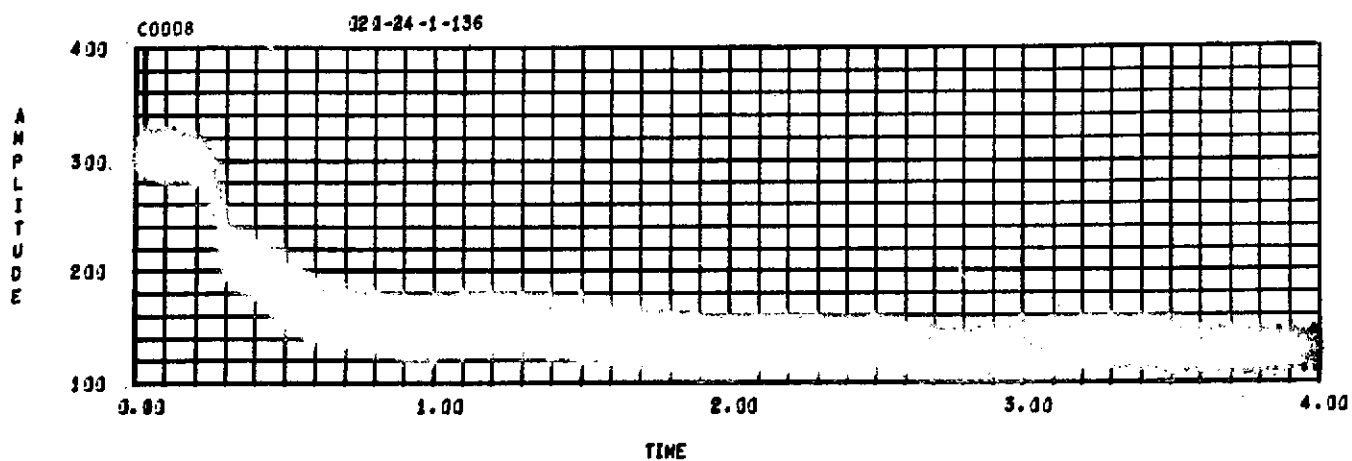
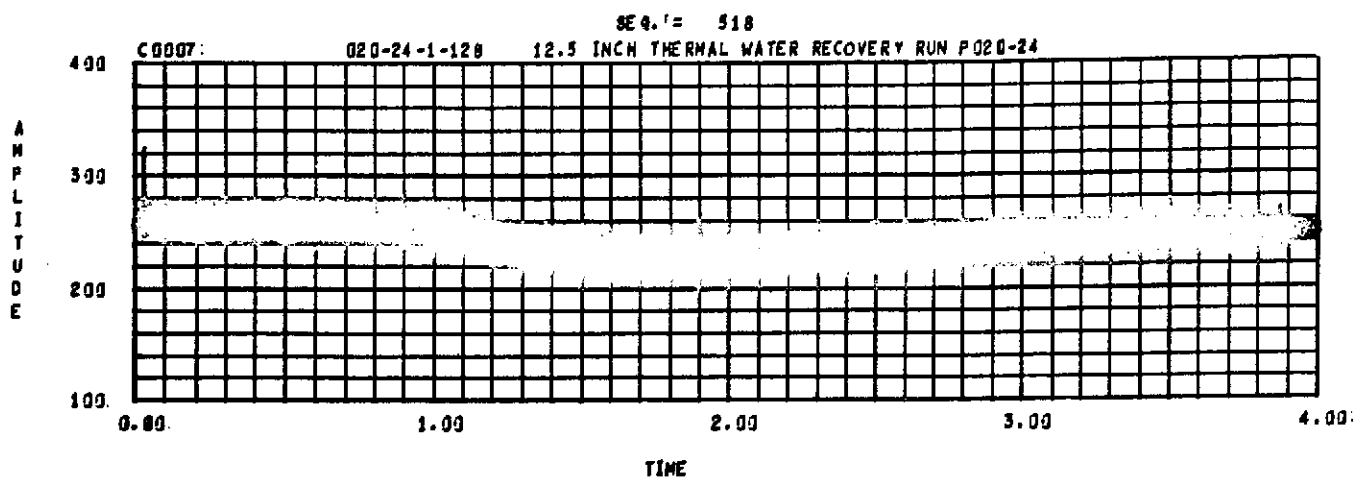
SEQ. = 518

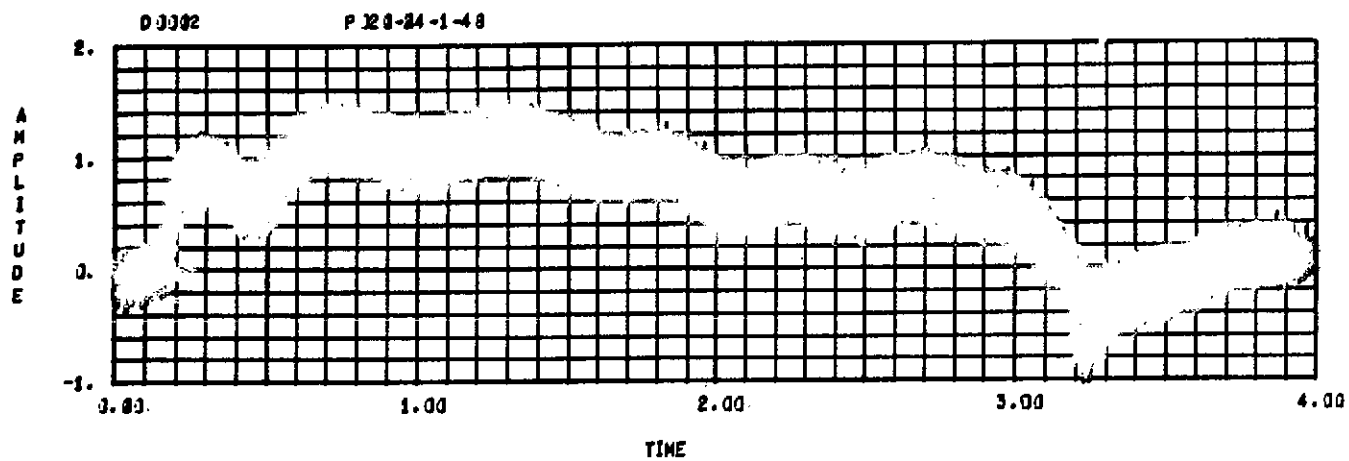
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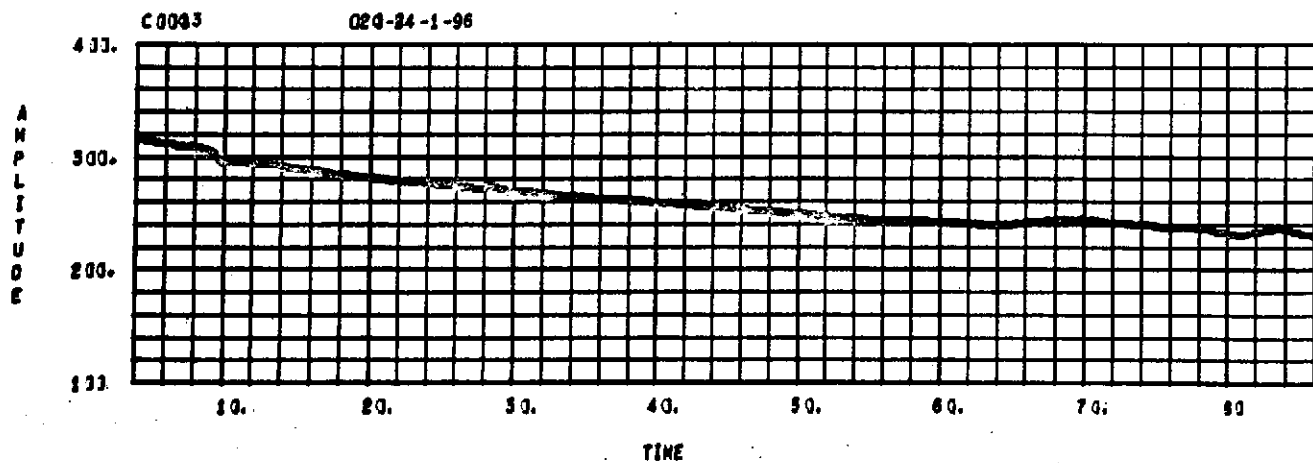
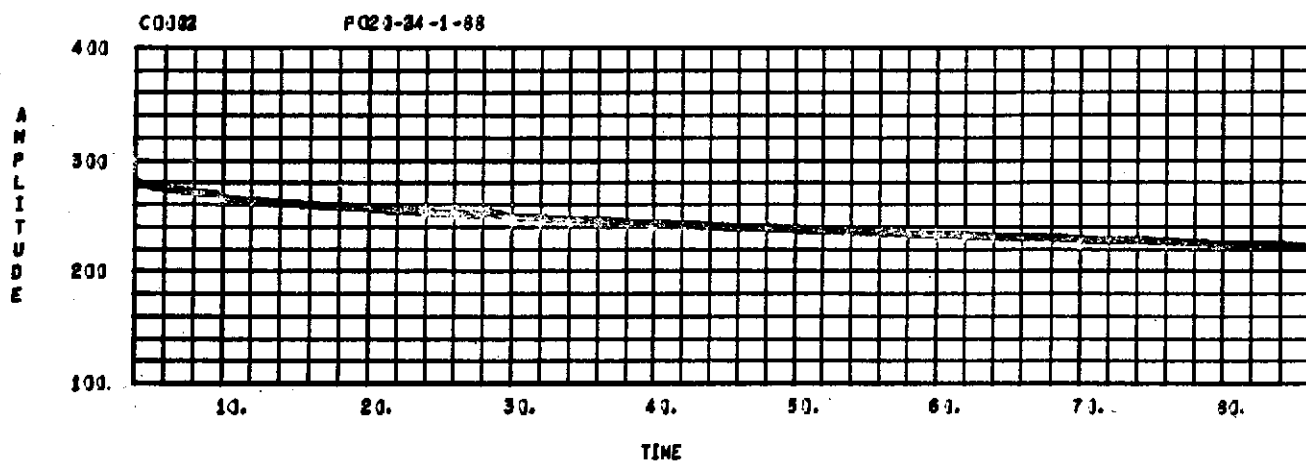
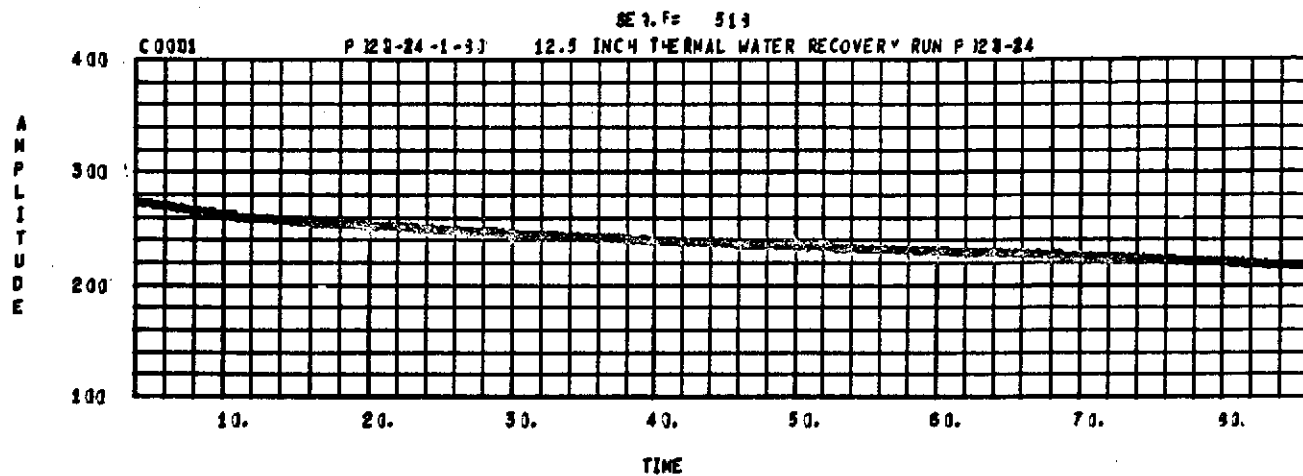


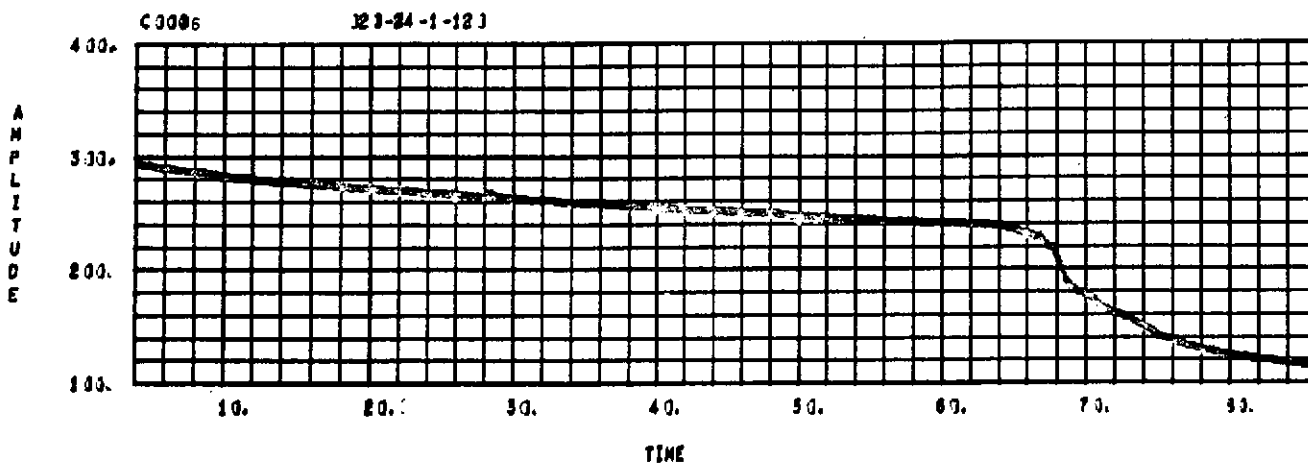
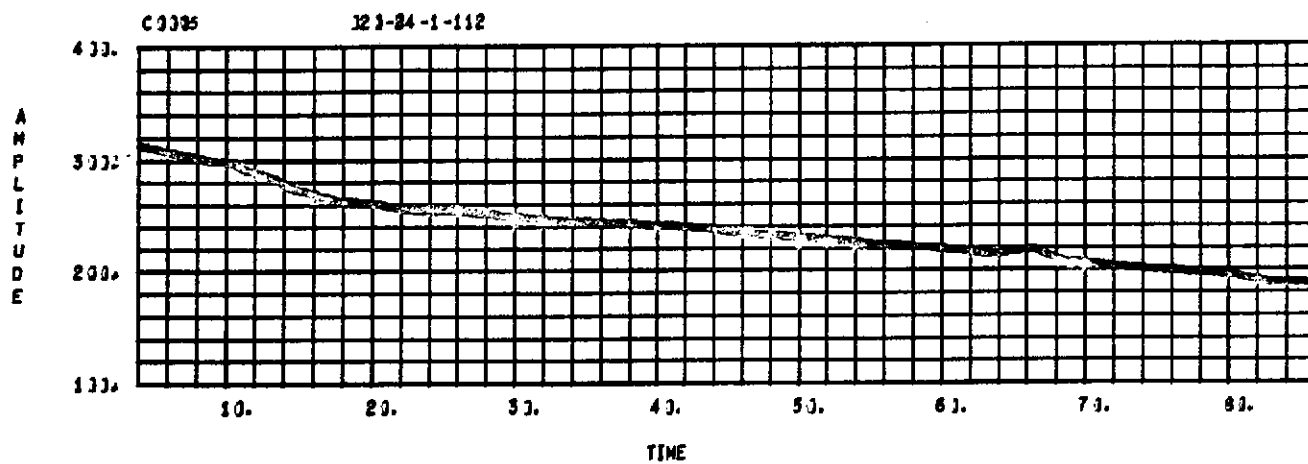
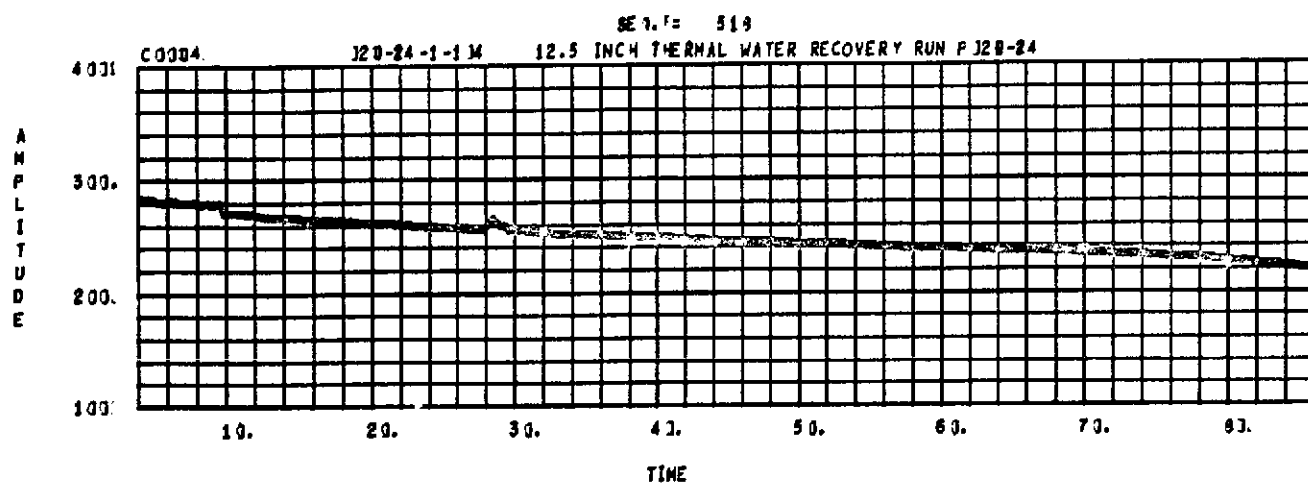


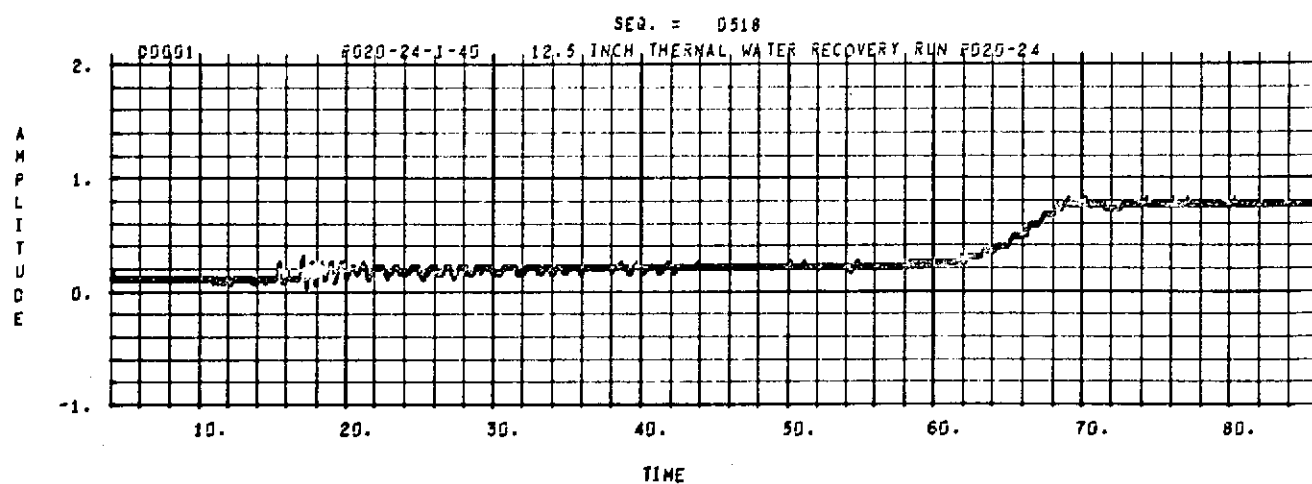
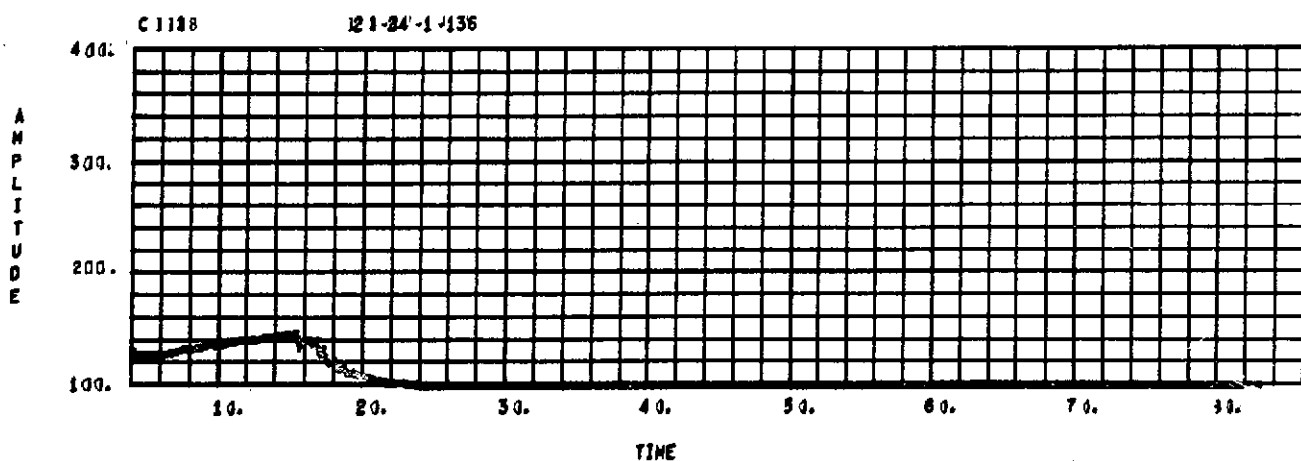
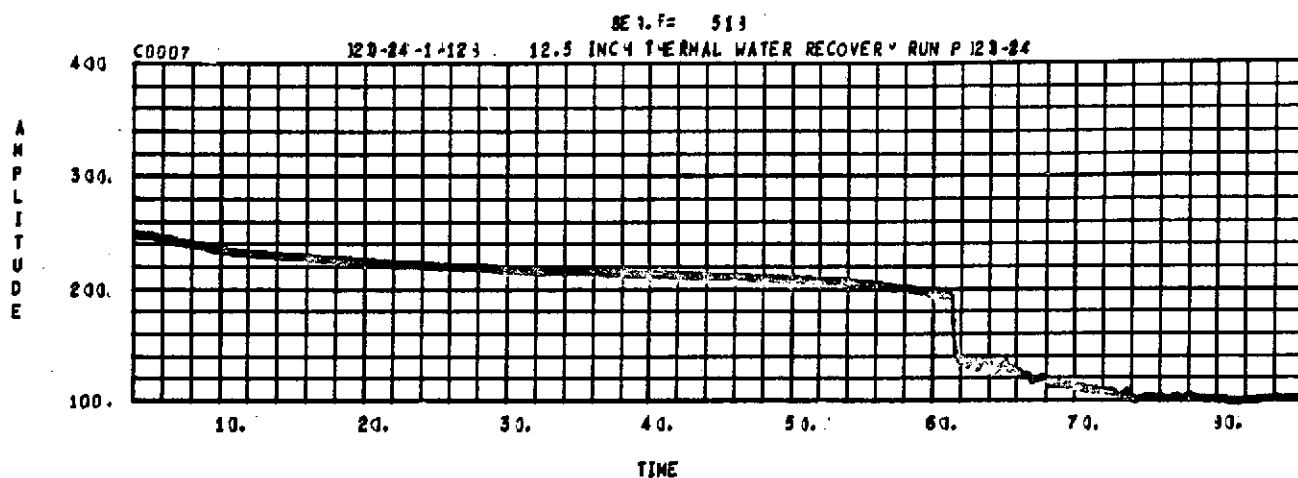


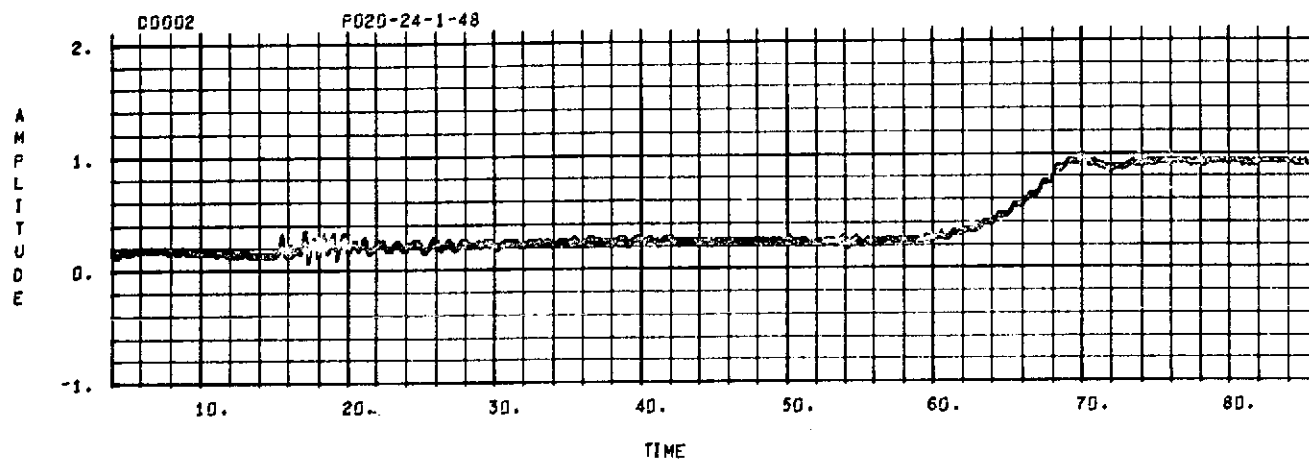


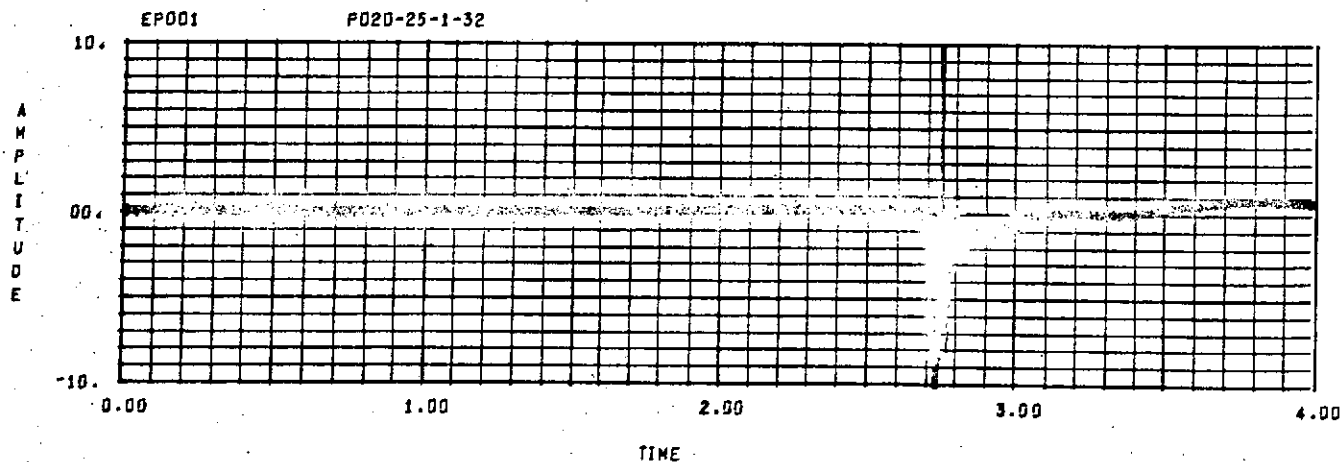
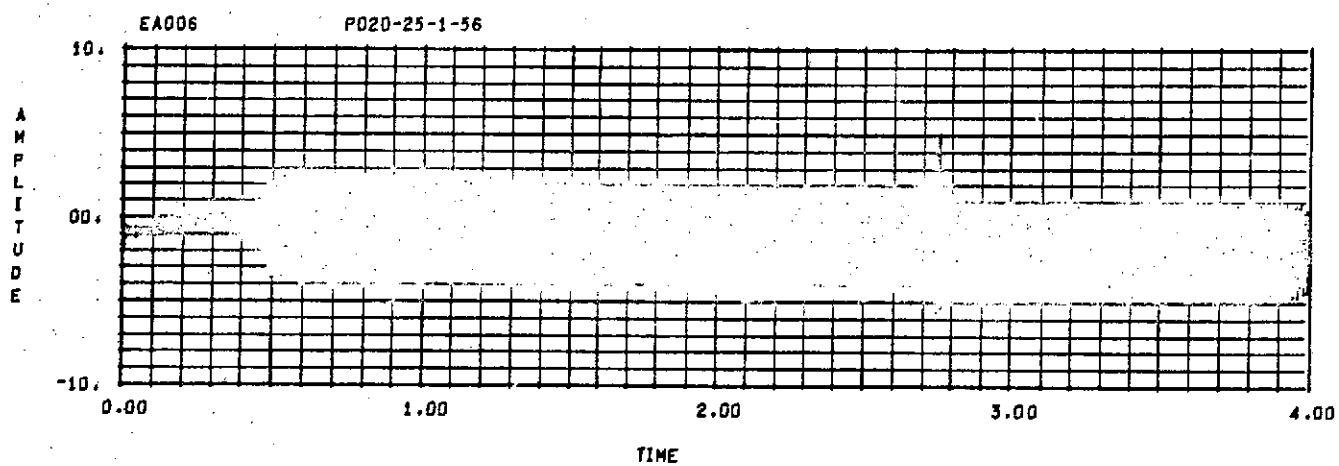
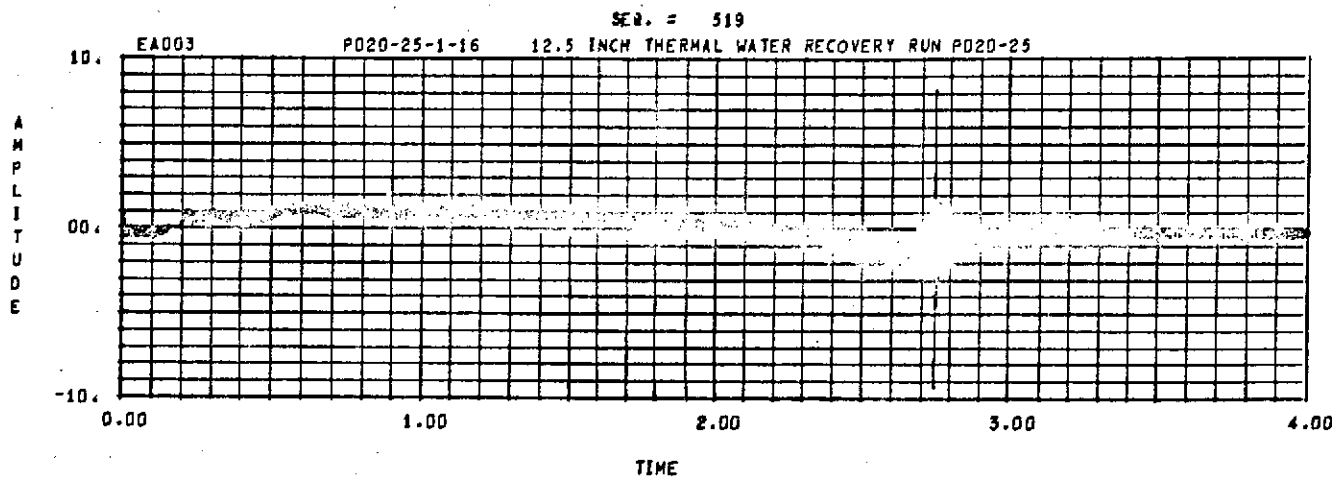






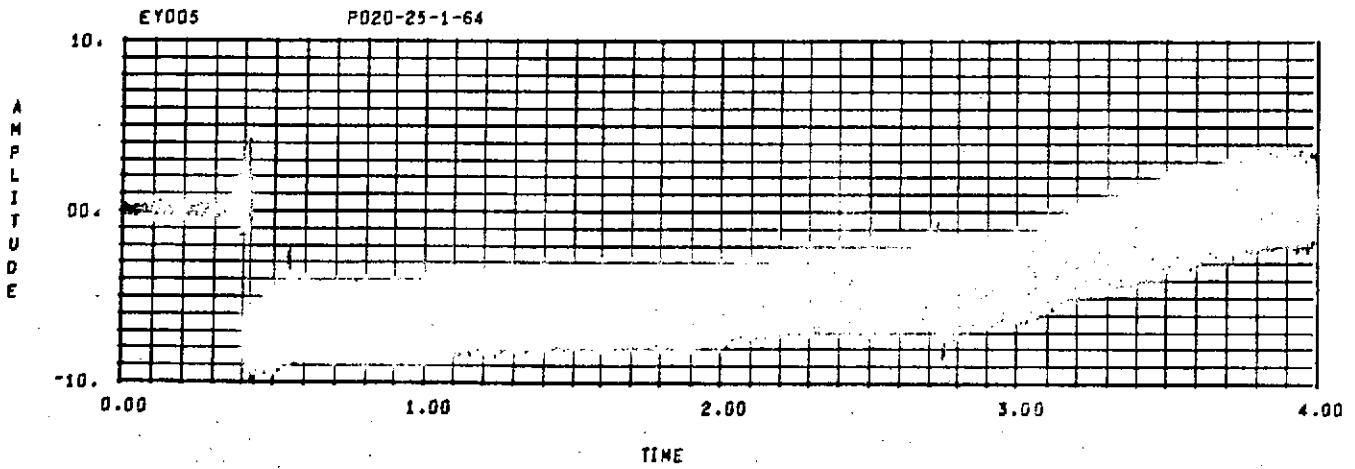
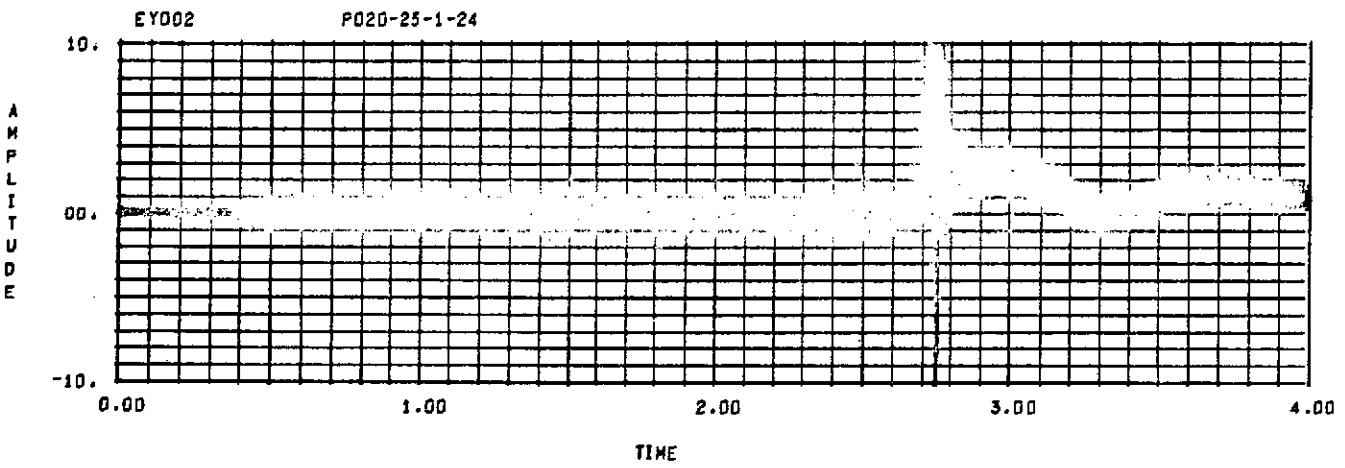
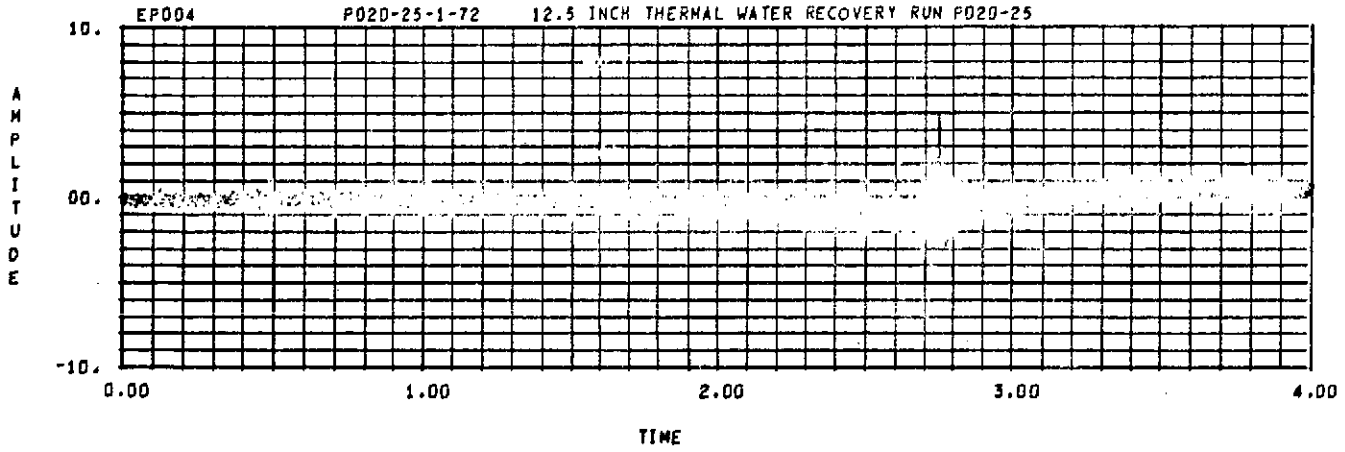


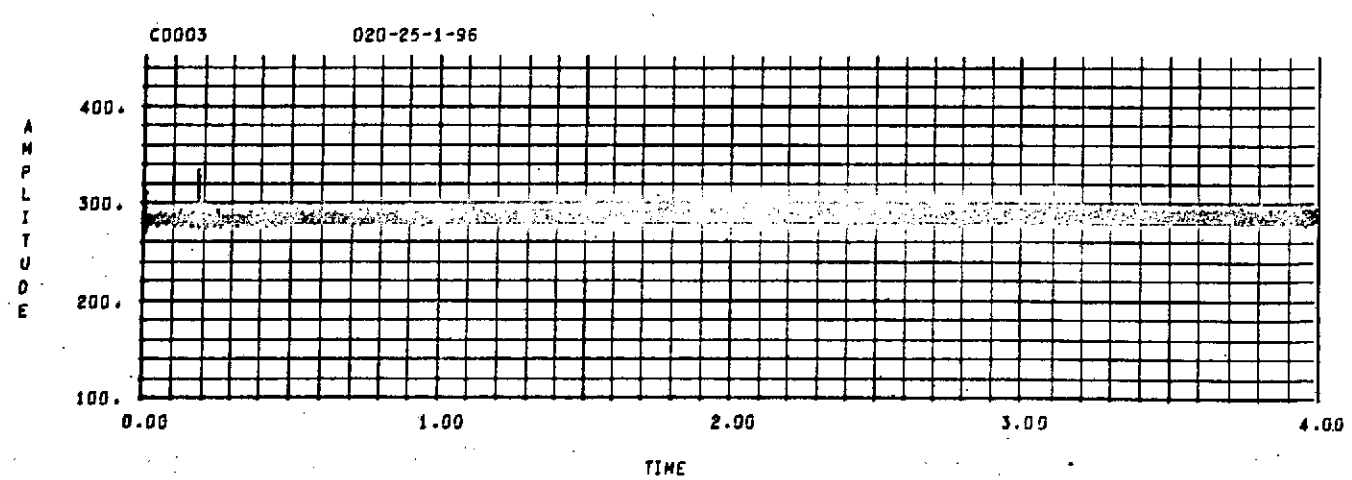
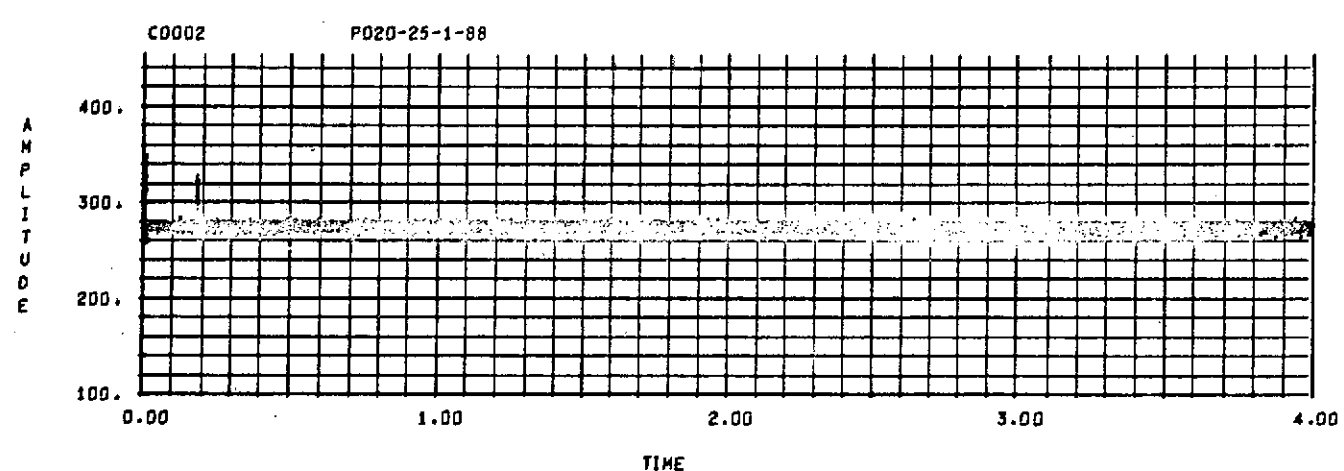
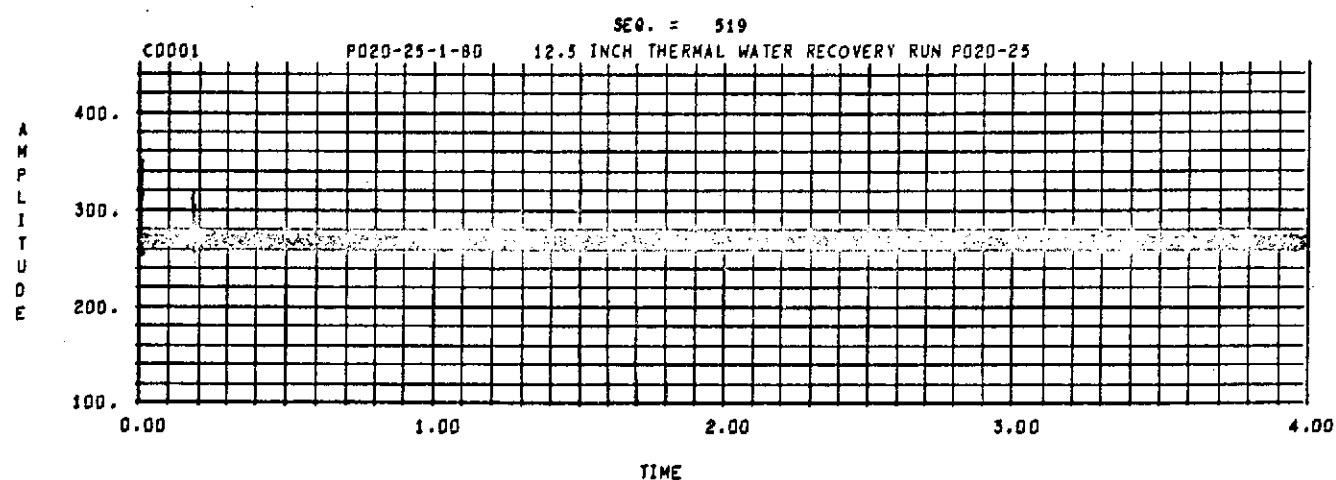




SEQ. = 519

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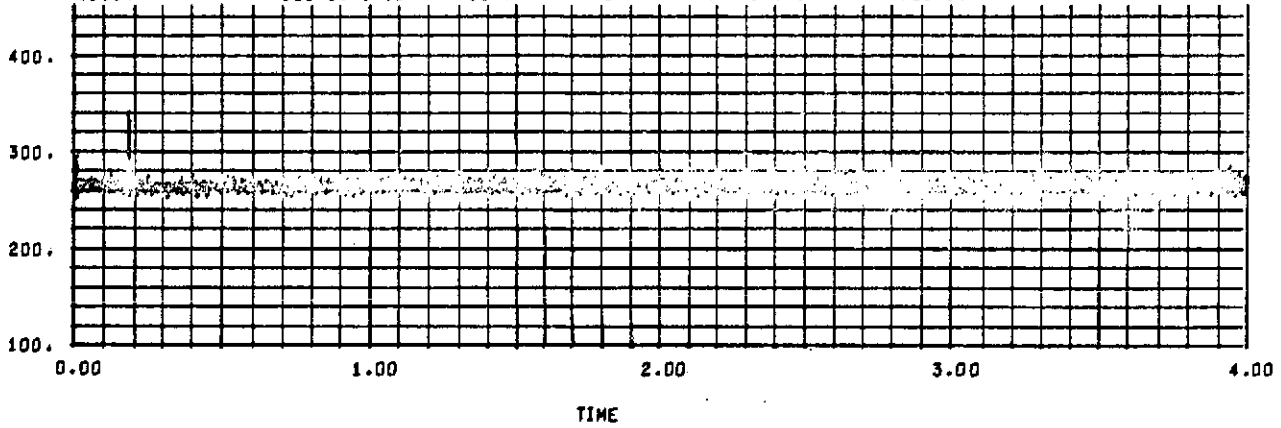


SEQ. = 519

4

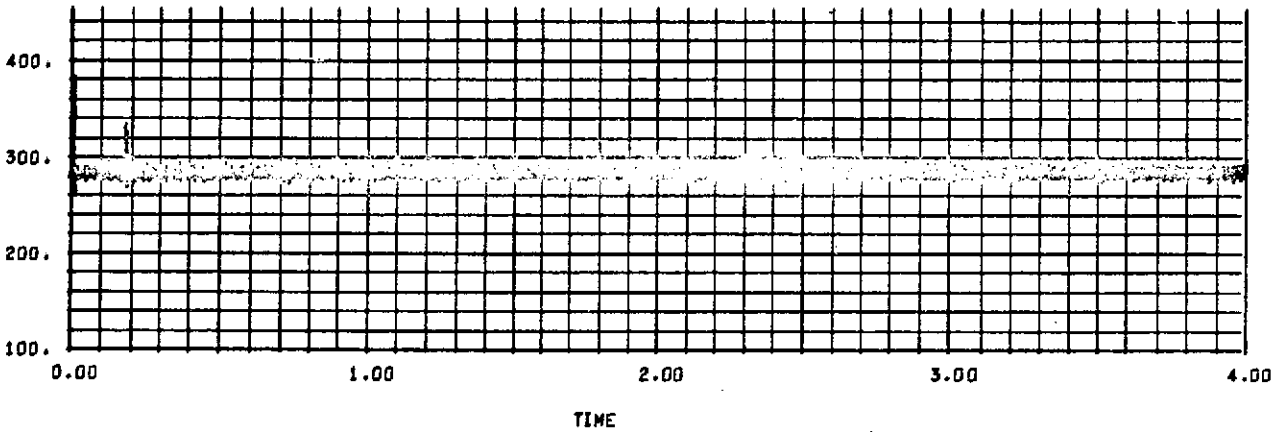
C0004 020-25-1-104 12.5 INCH THERMAL WATER RECOVERY RUN P020-25

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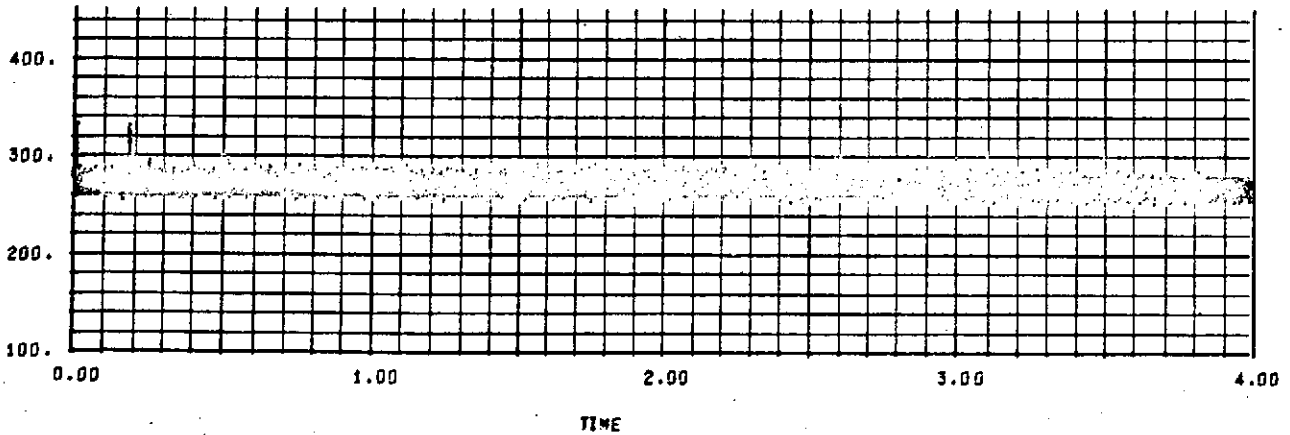
C0005 020-25-1-112

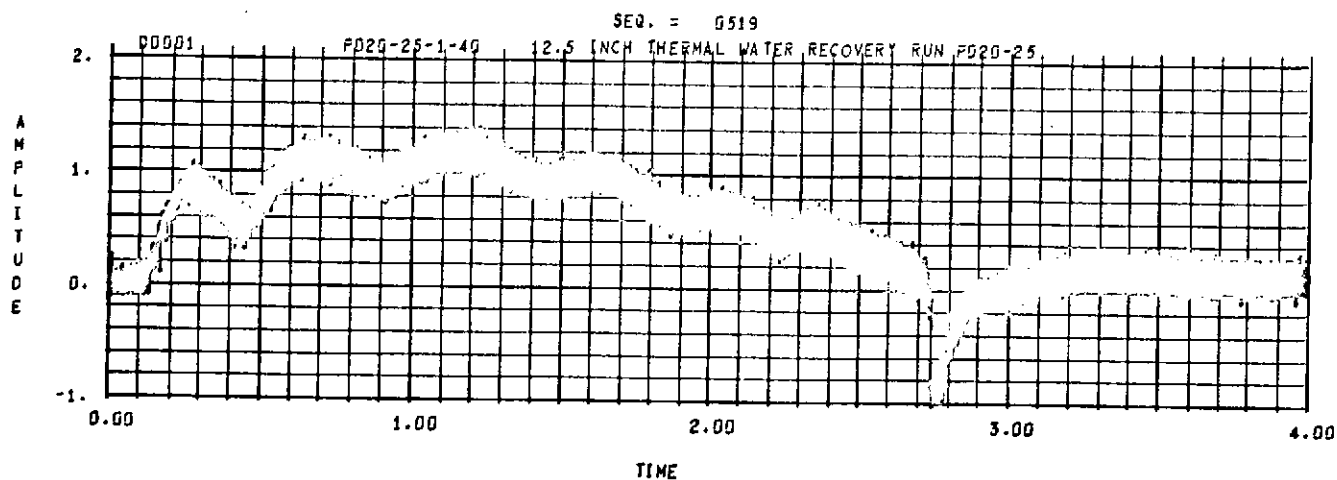
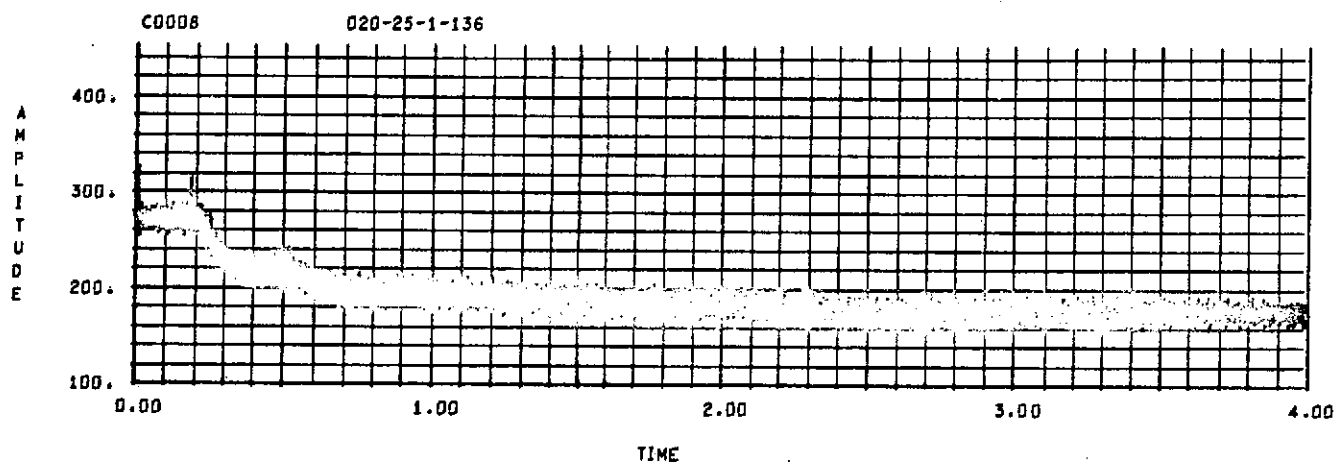
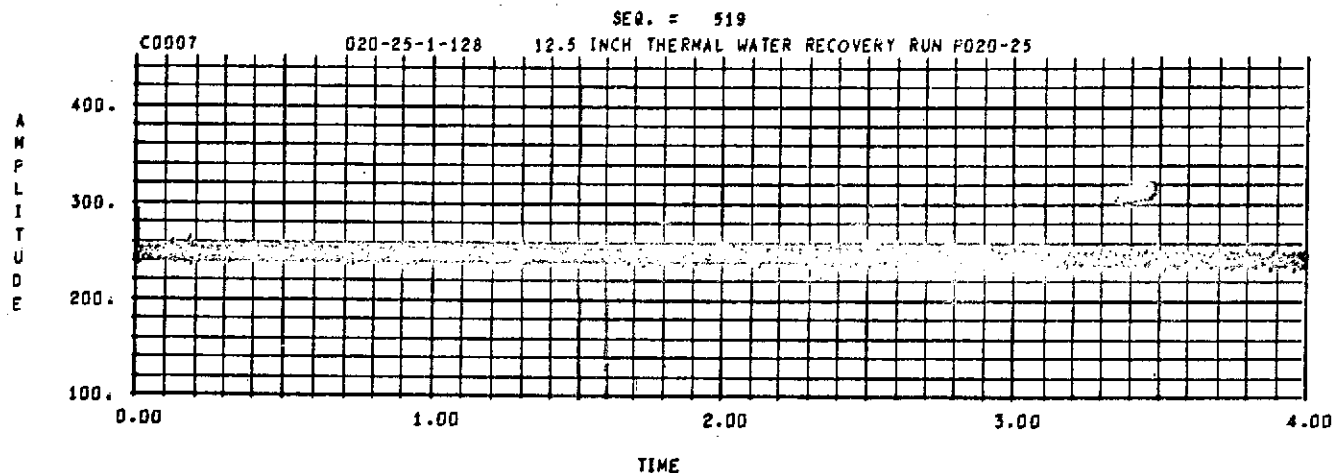
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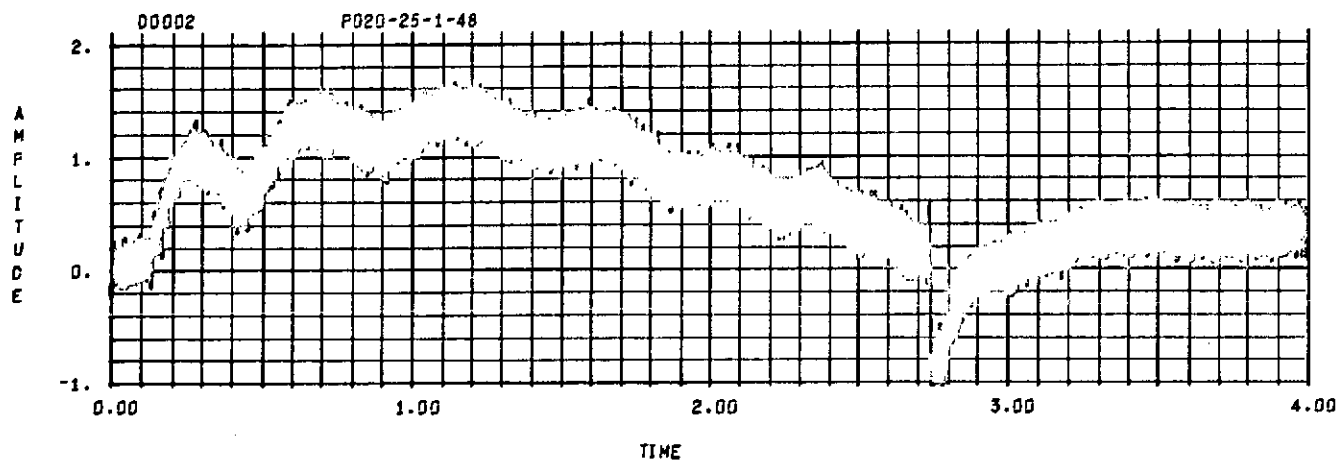


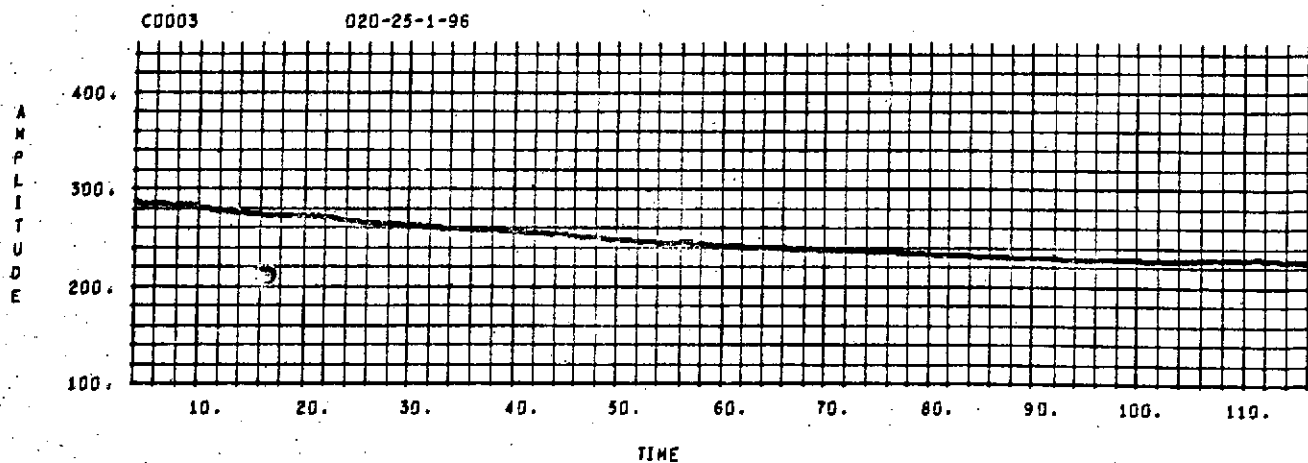
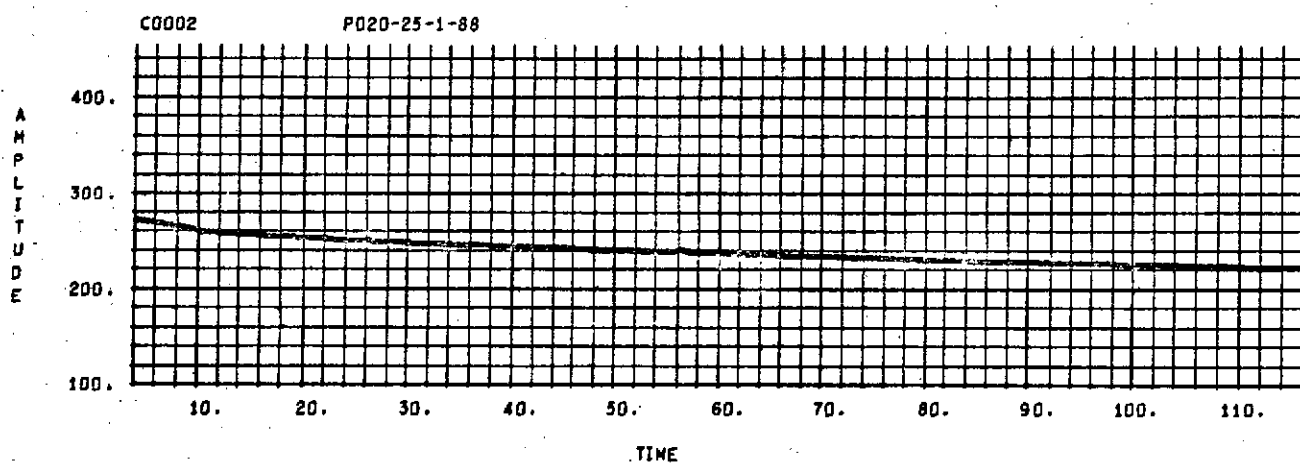
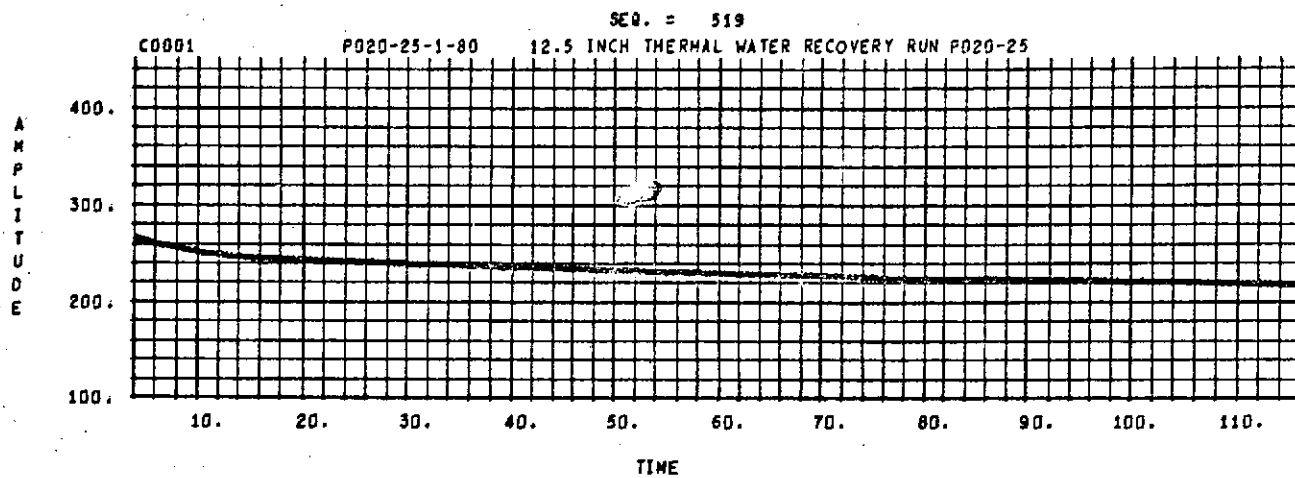
C0006 020-25-1-120

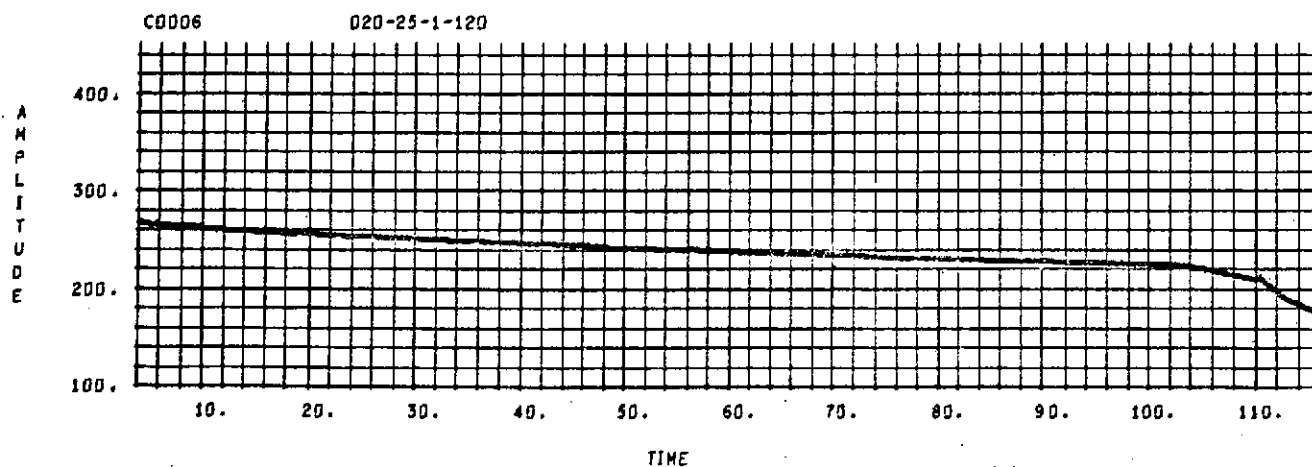
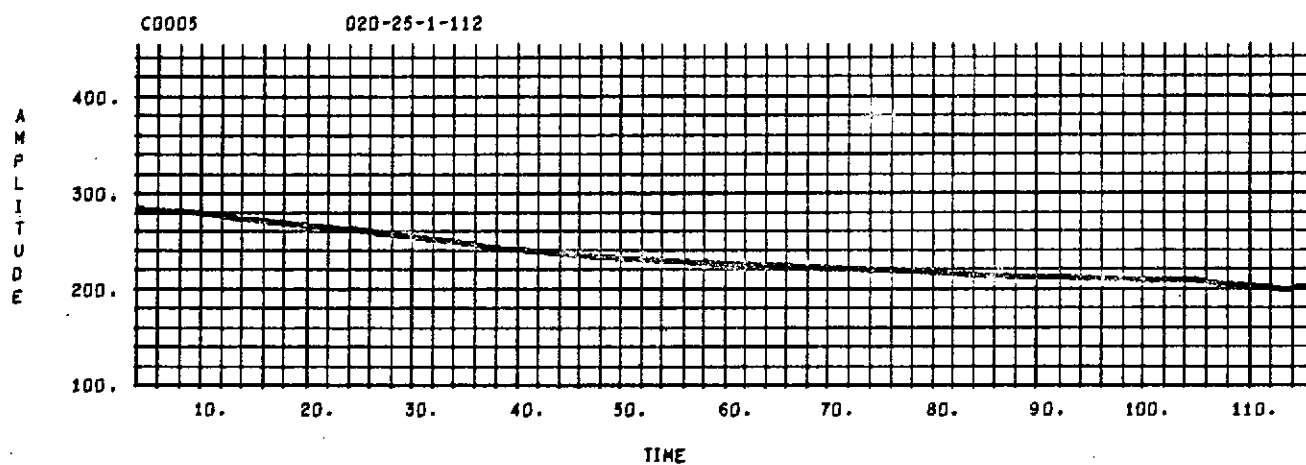
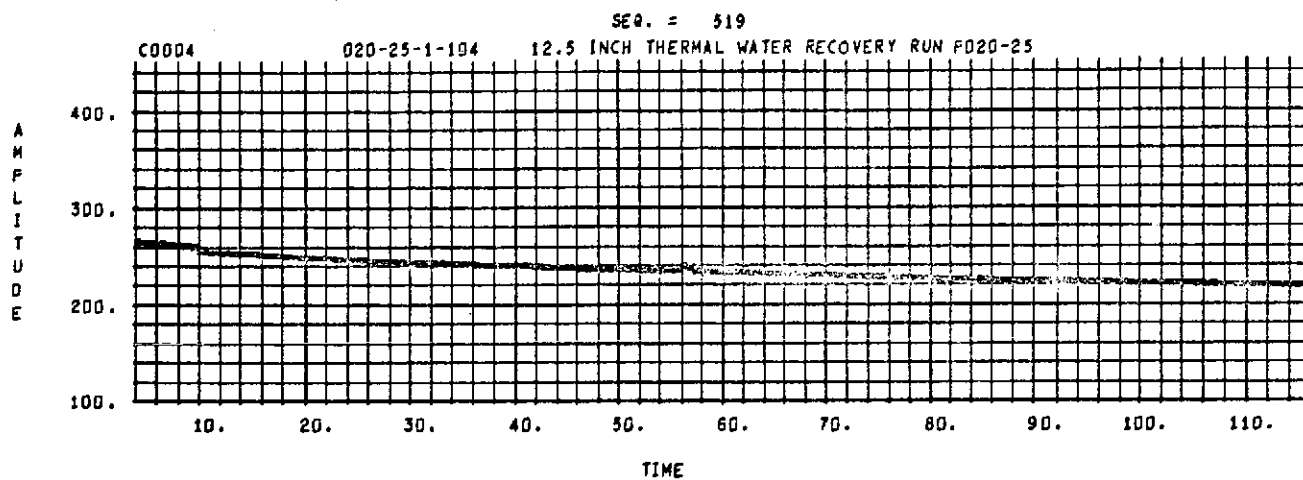
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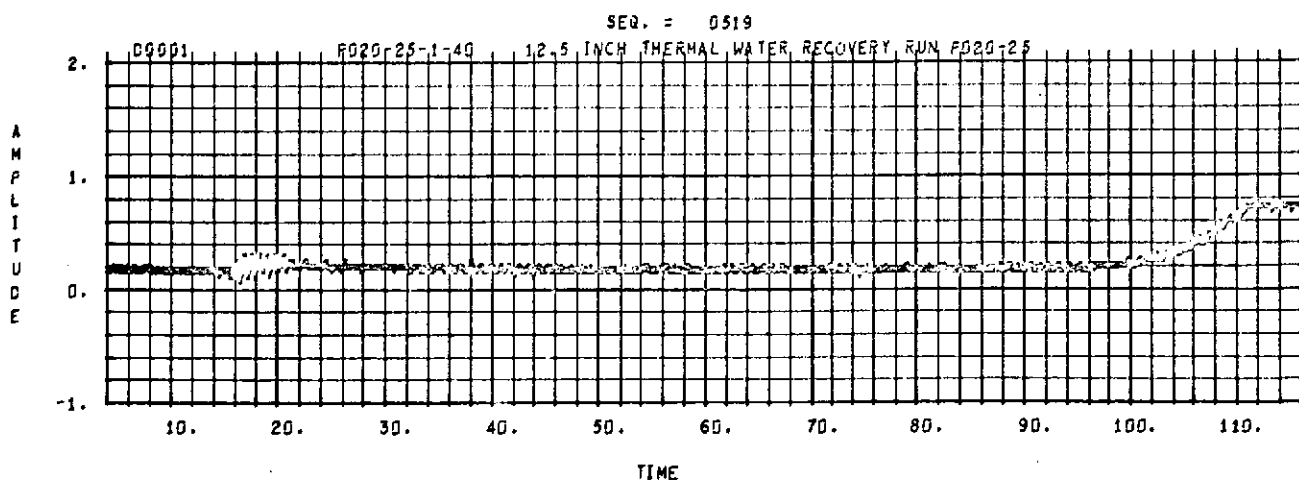
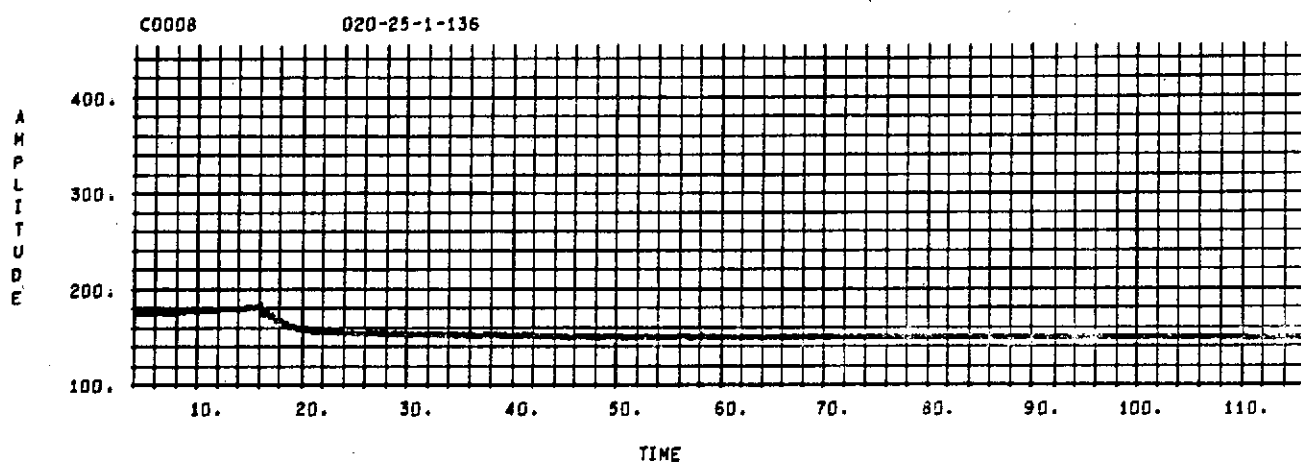
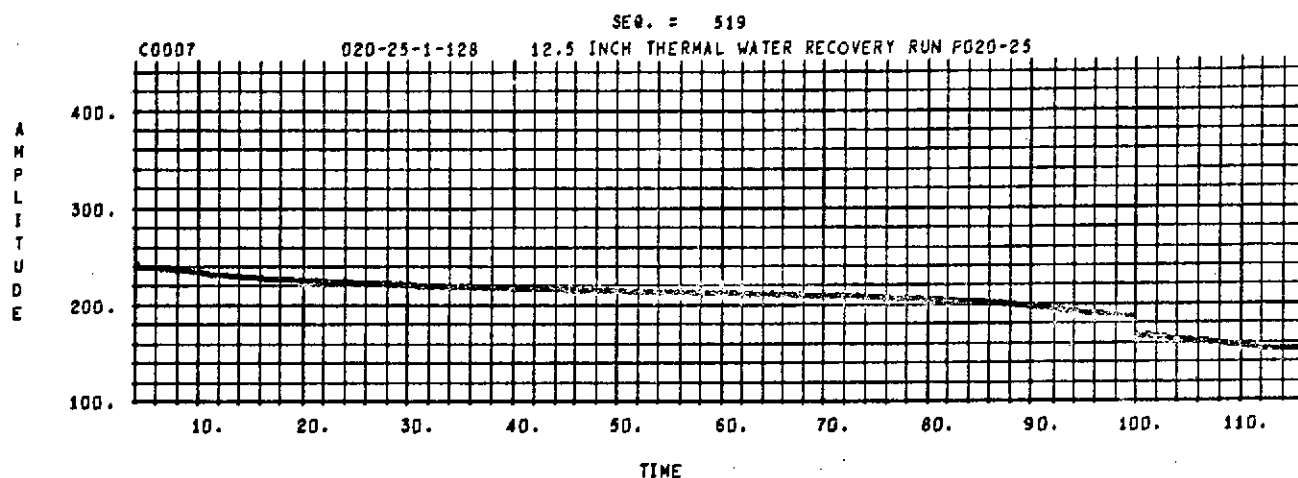


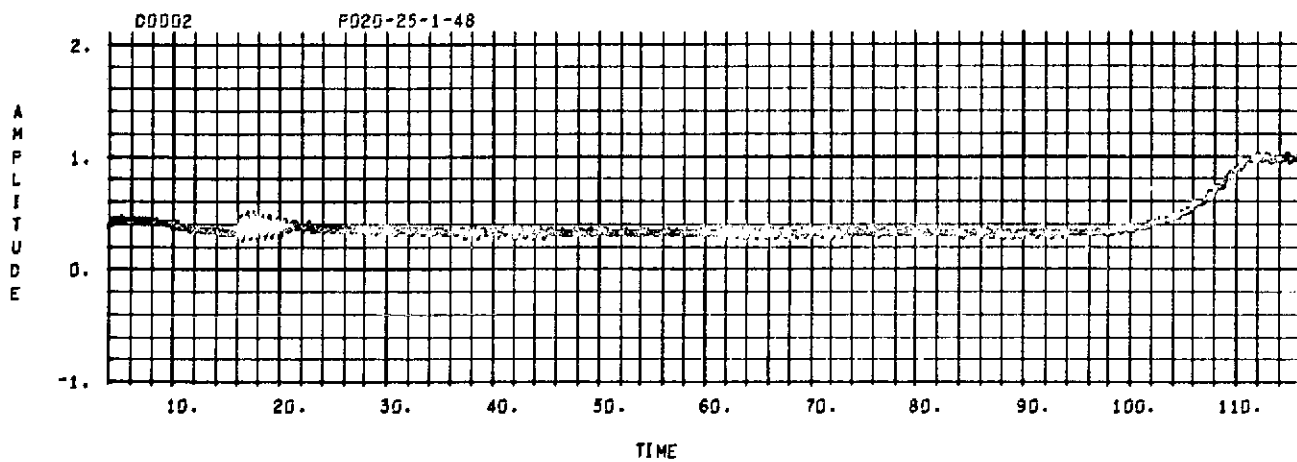






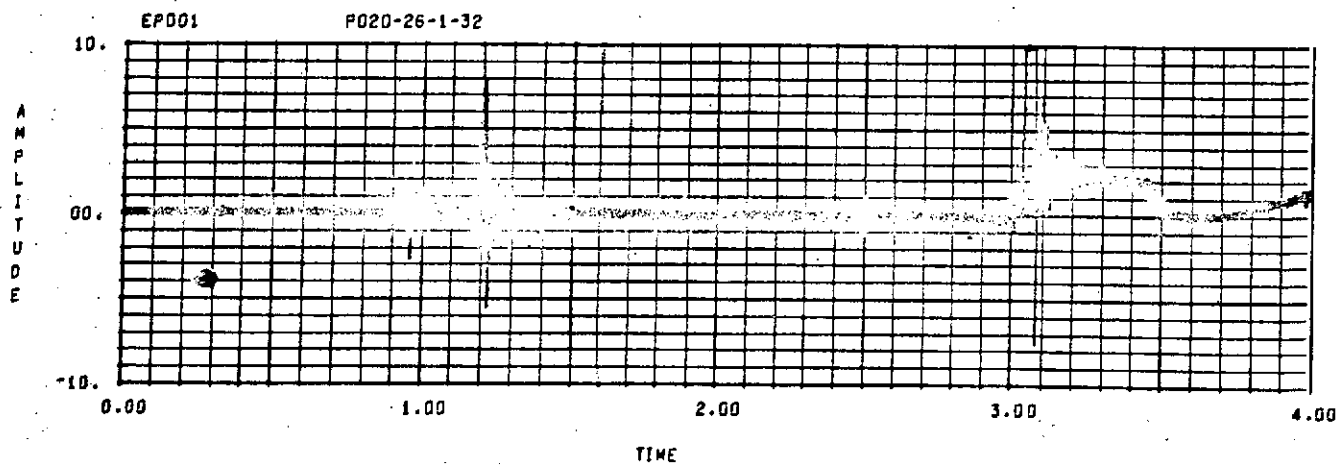
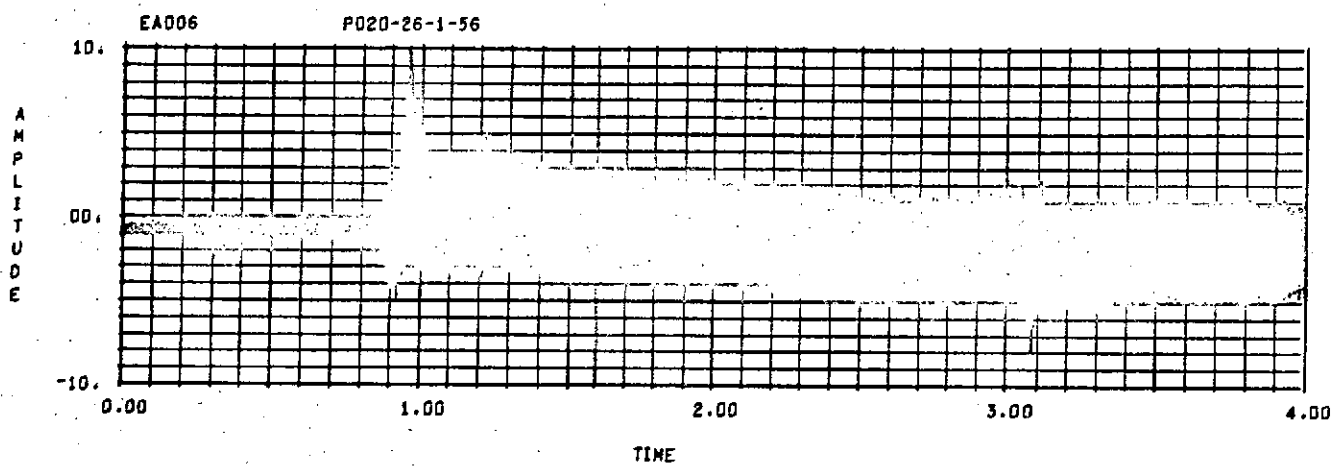
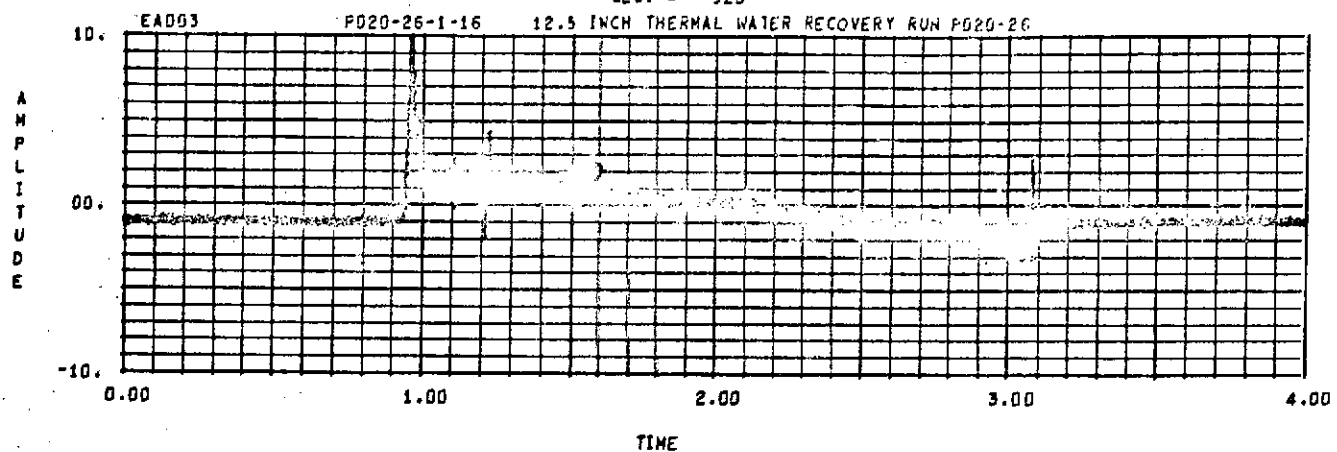






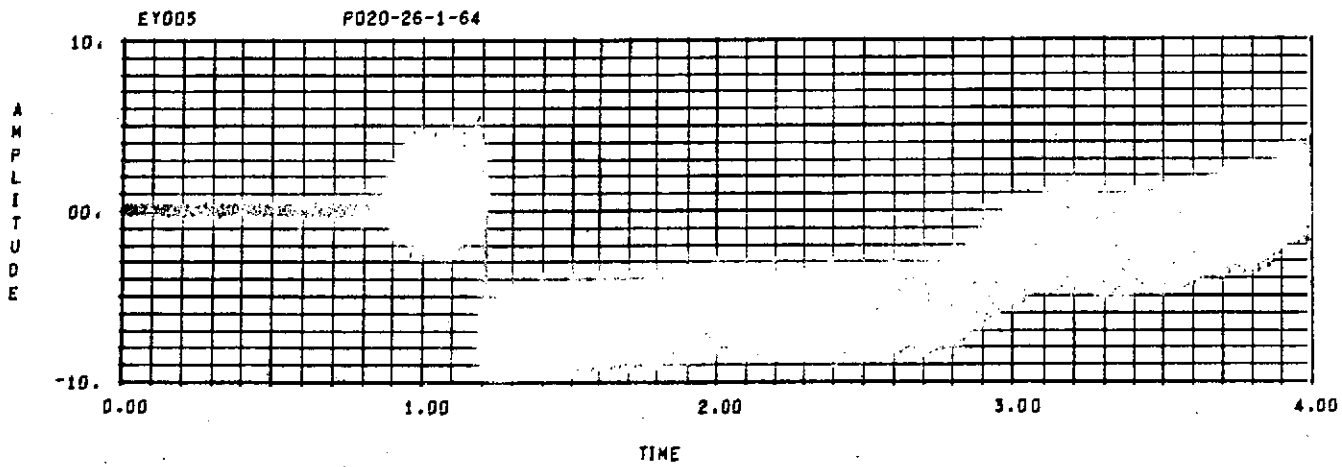
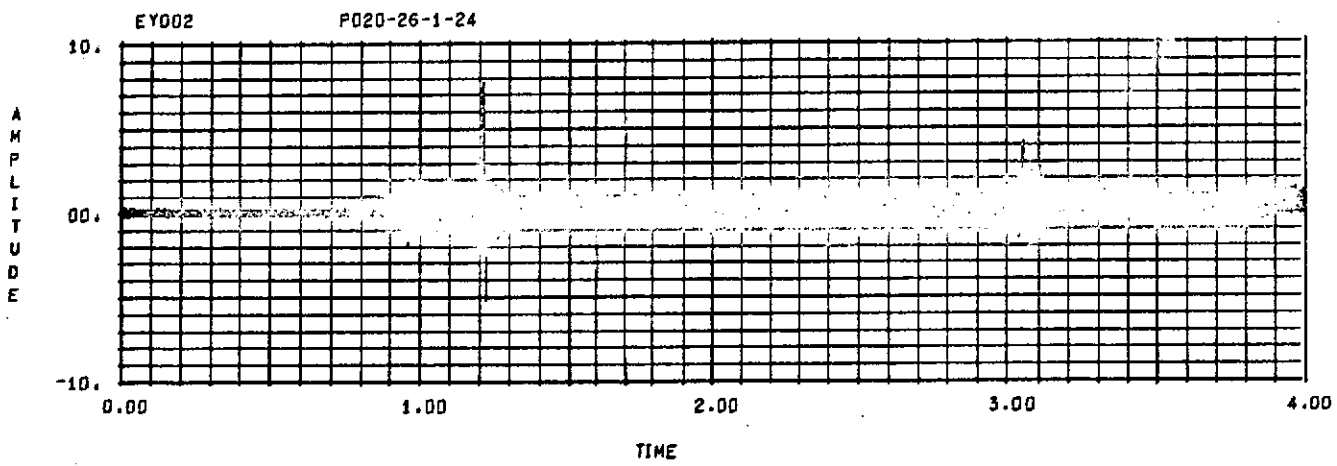
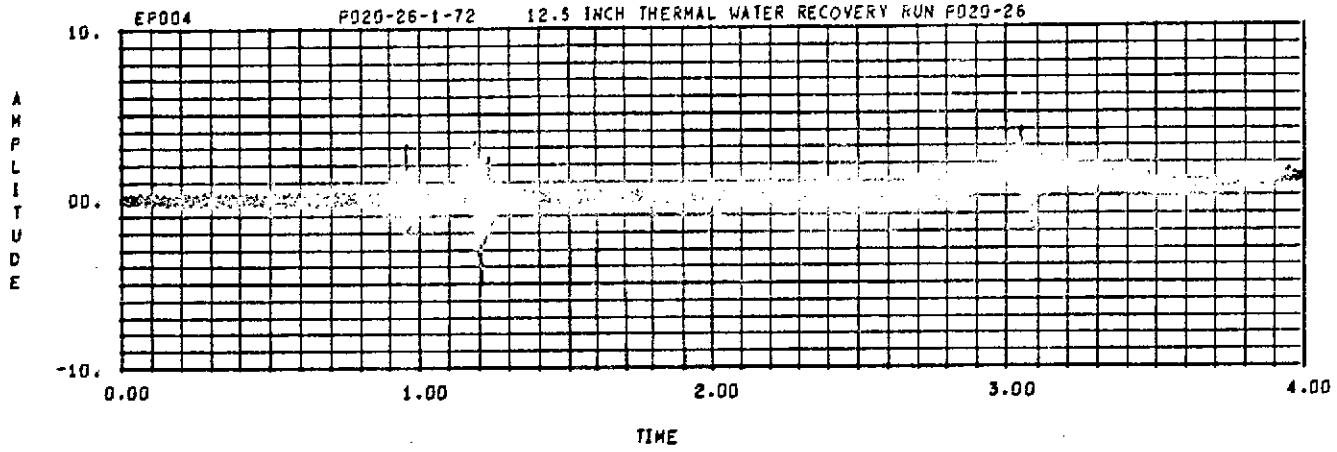
SEQ. = 520

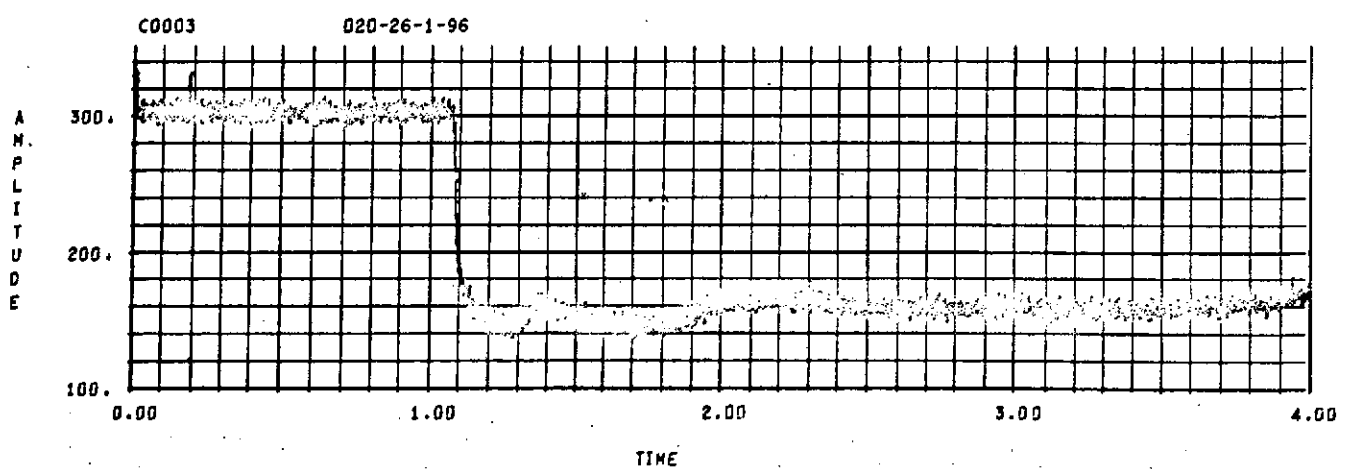
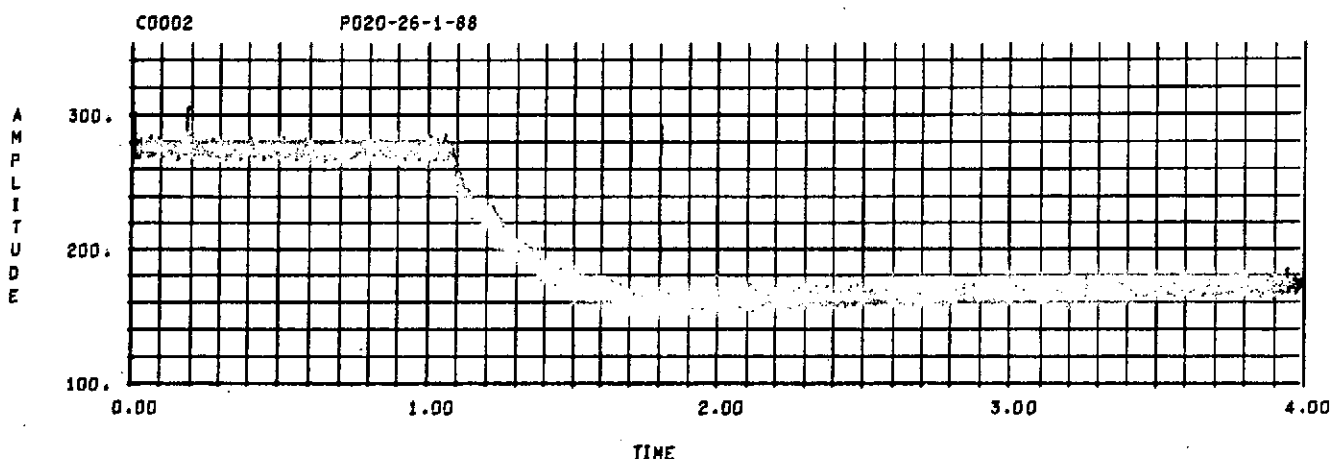
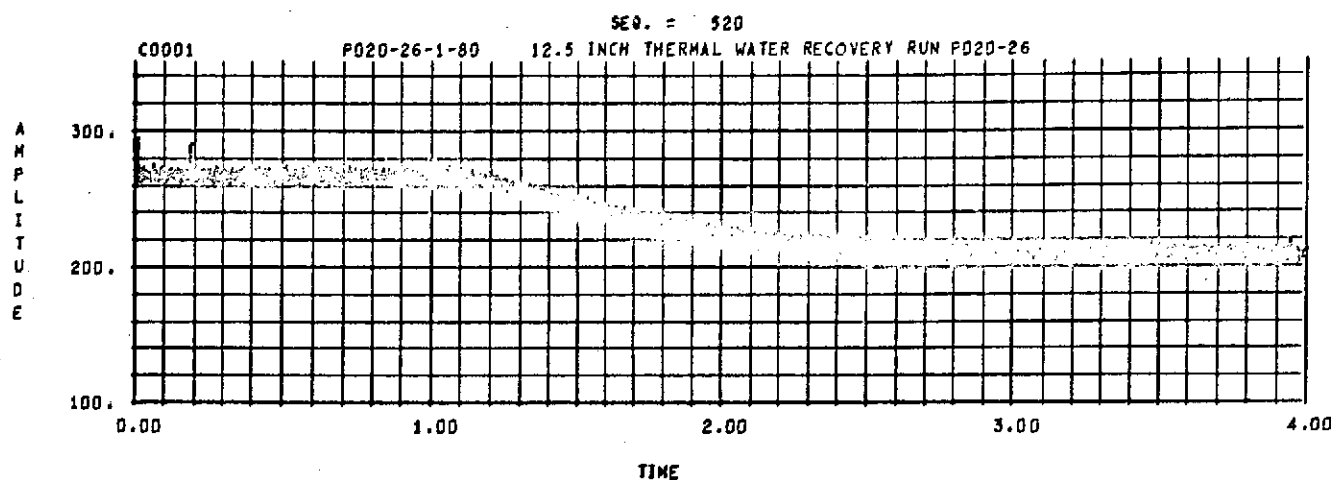
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SEQ. = 520

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SEQ. = 520

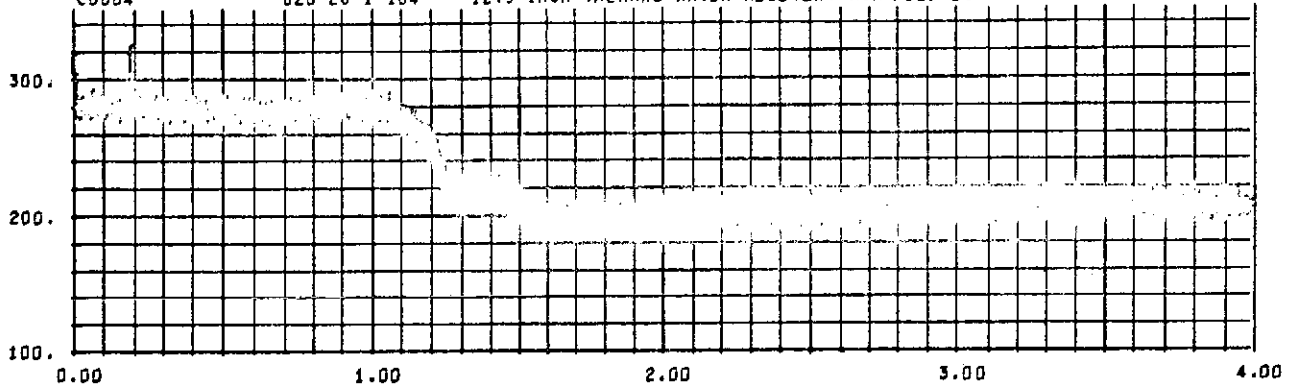
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C0004

020-26-1-104

12.5 INCH THERMAL WATER RECOVERY RUN P020-26

AMPLITUDE

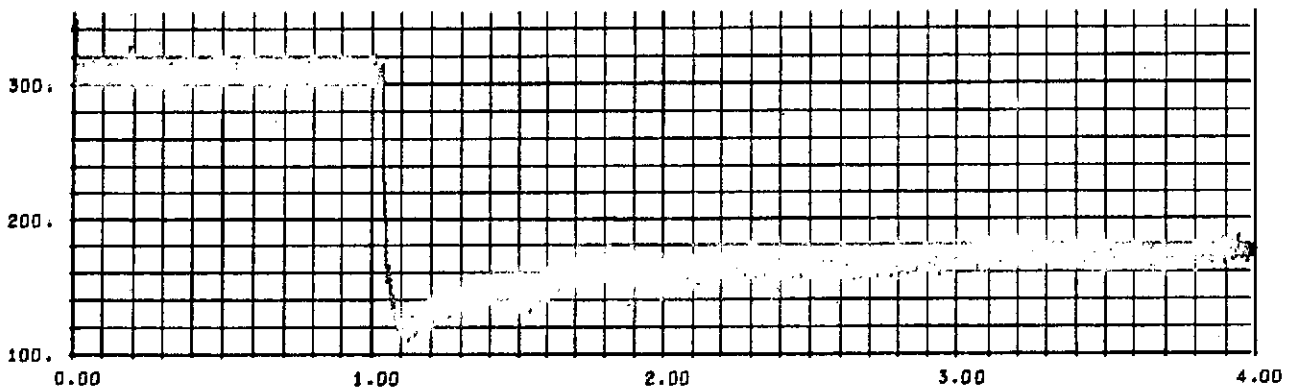


TIME

C0005

020-26-1-112

AMPLITUDE

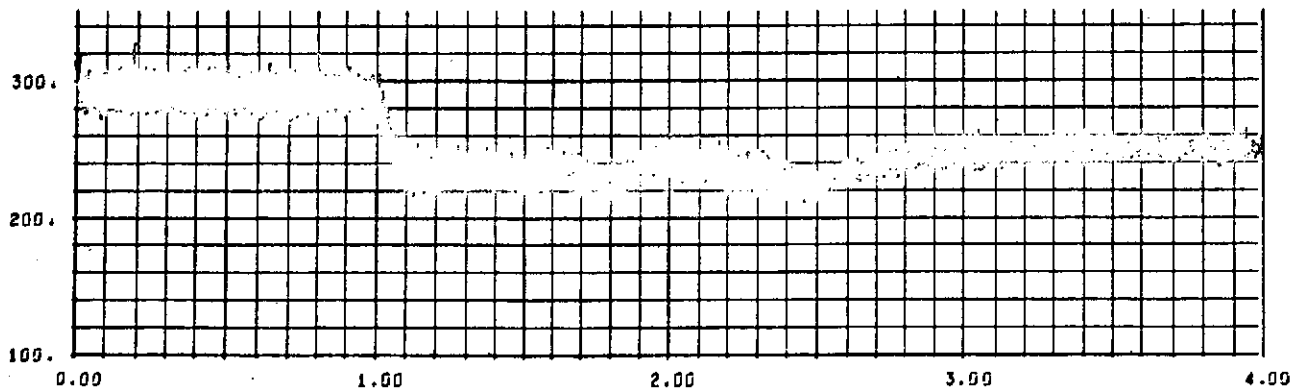


TIME

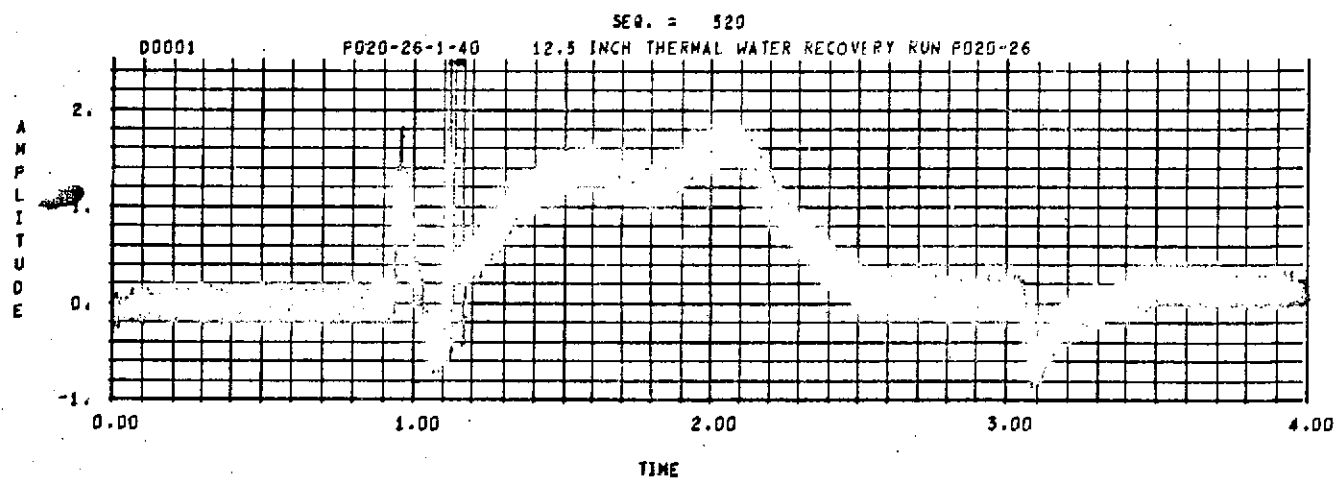
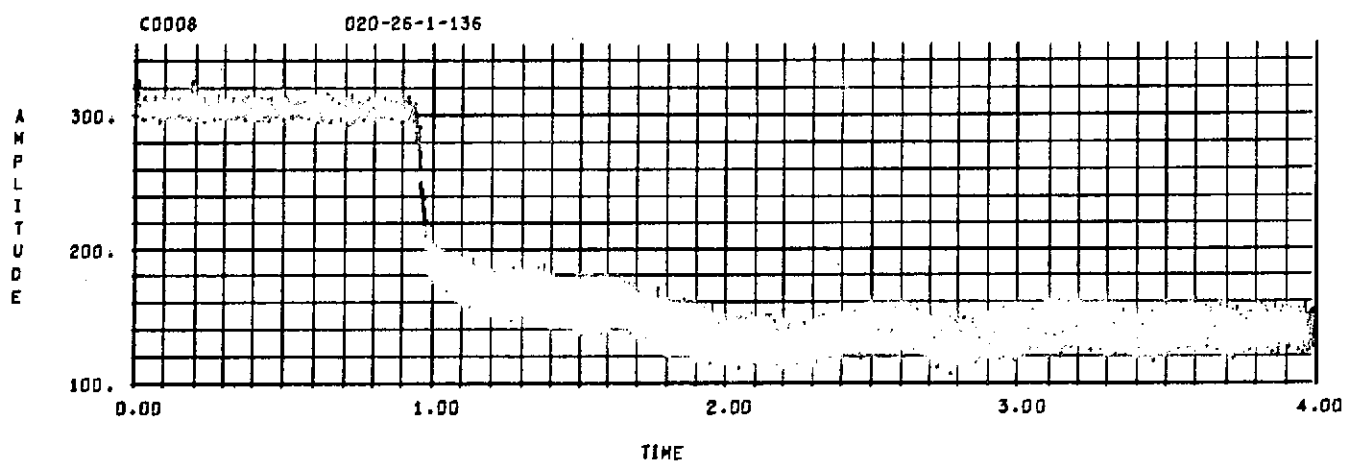
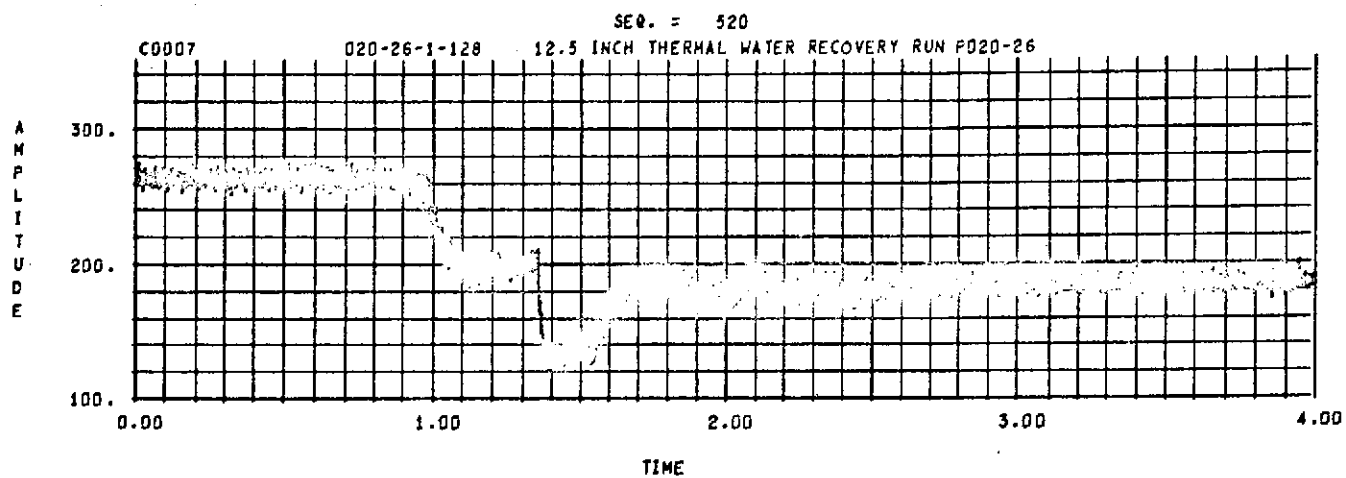
C0006

020-26-1-120

AMPLITUDE

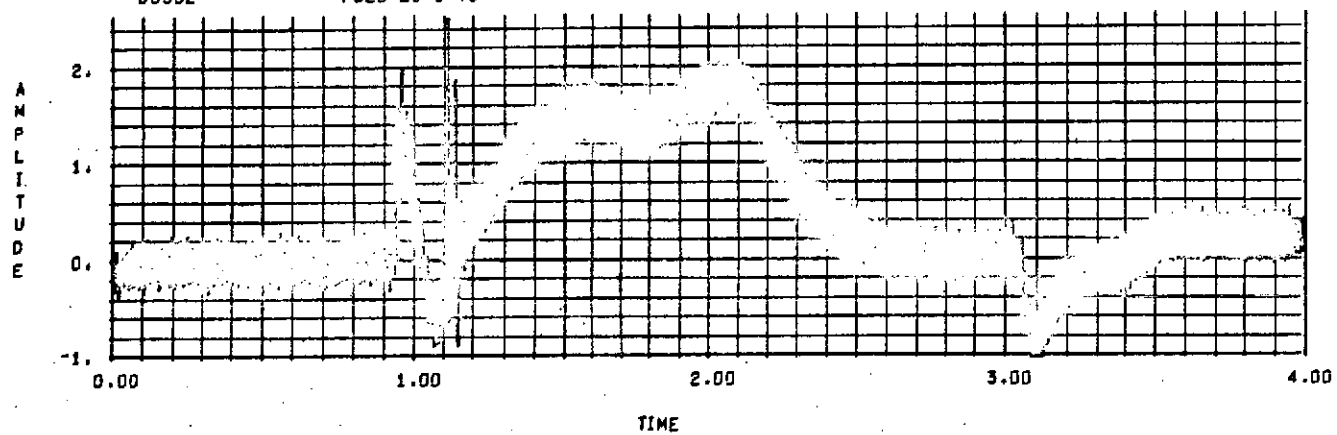


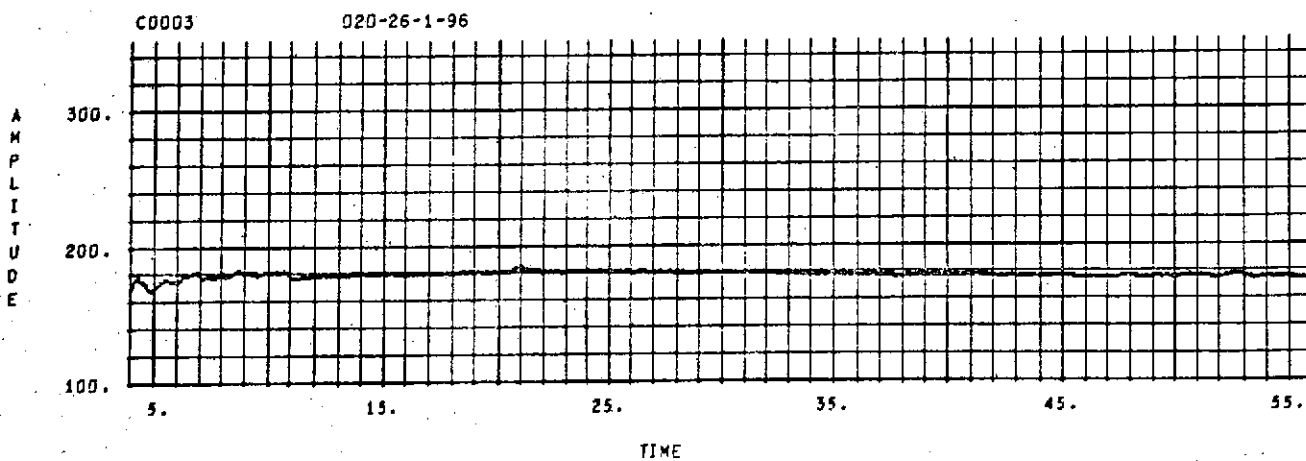
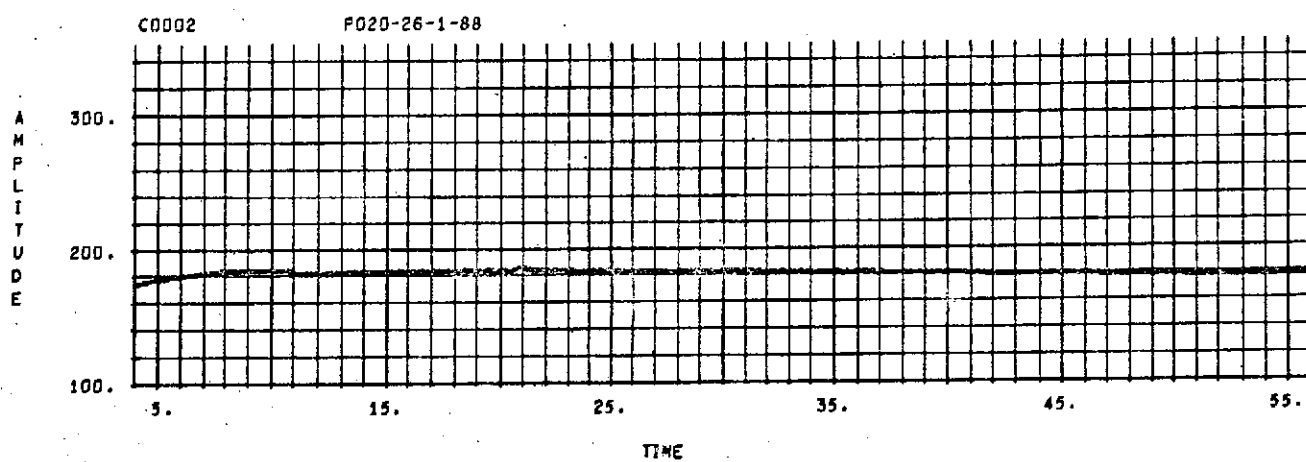
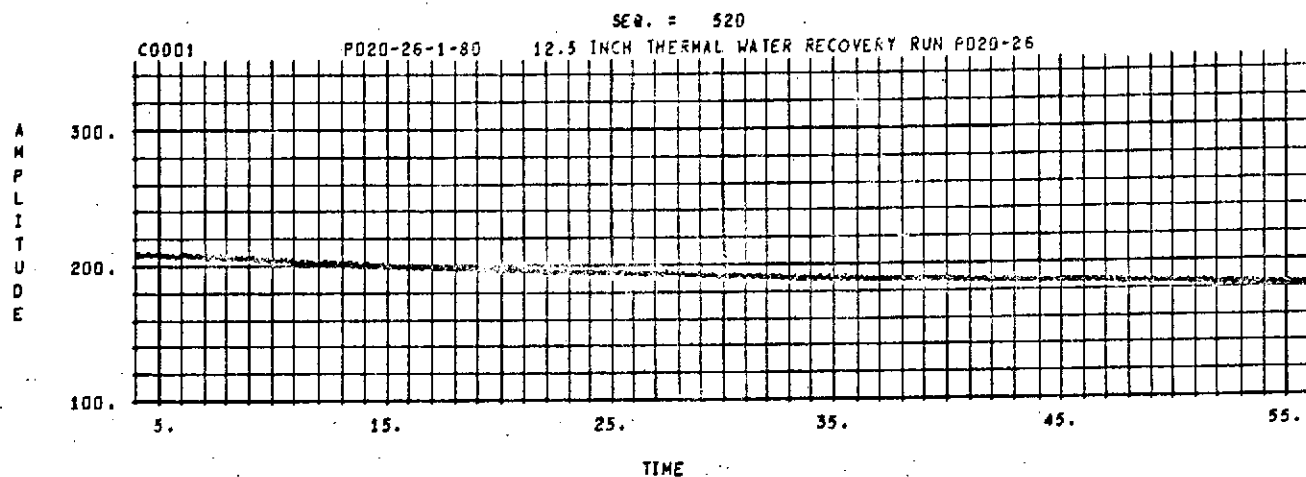
TIME

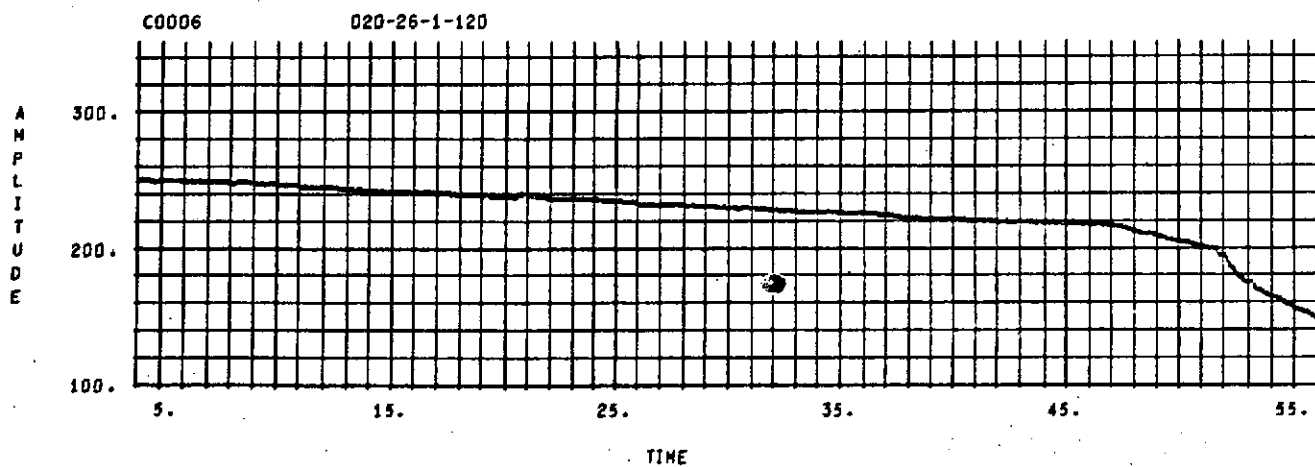
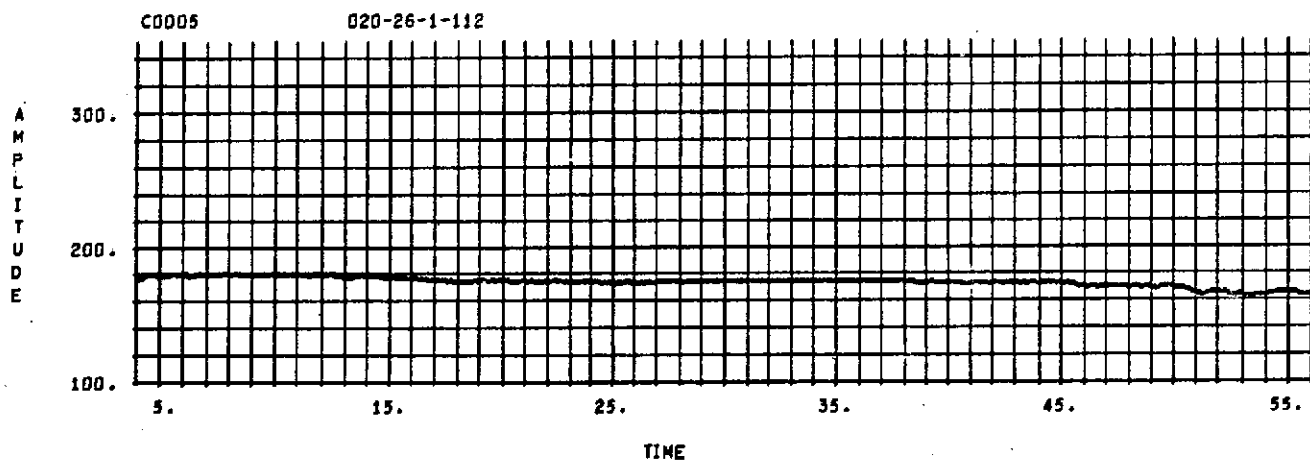
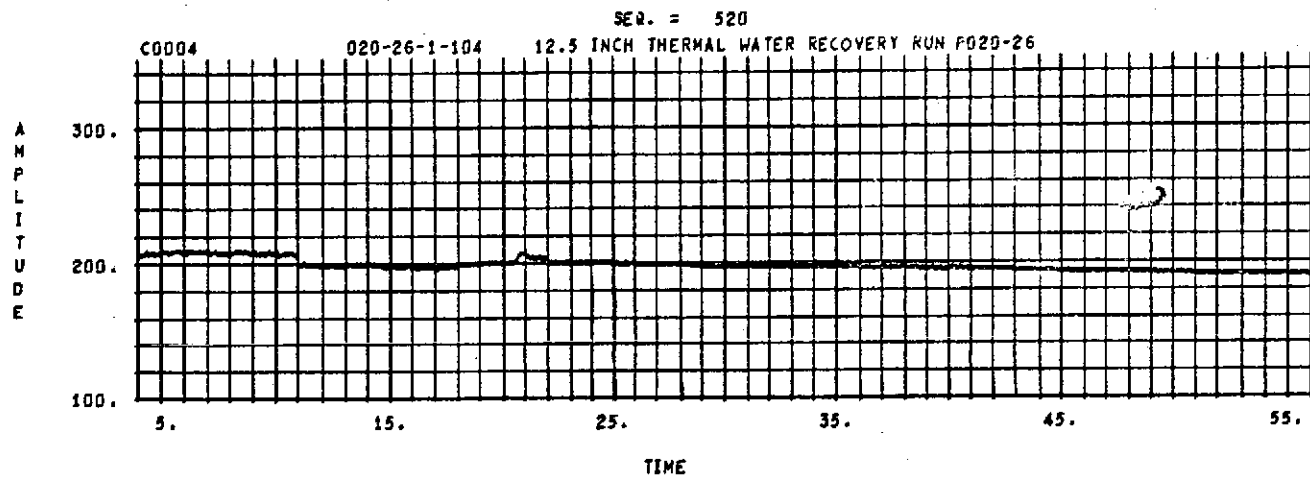


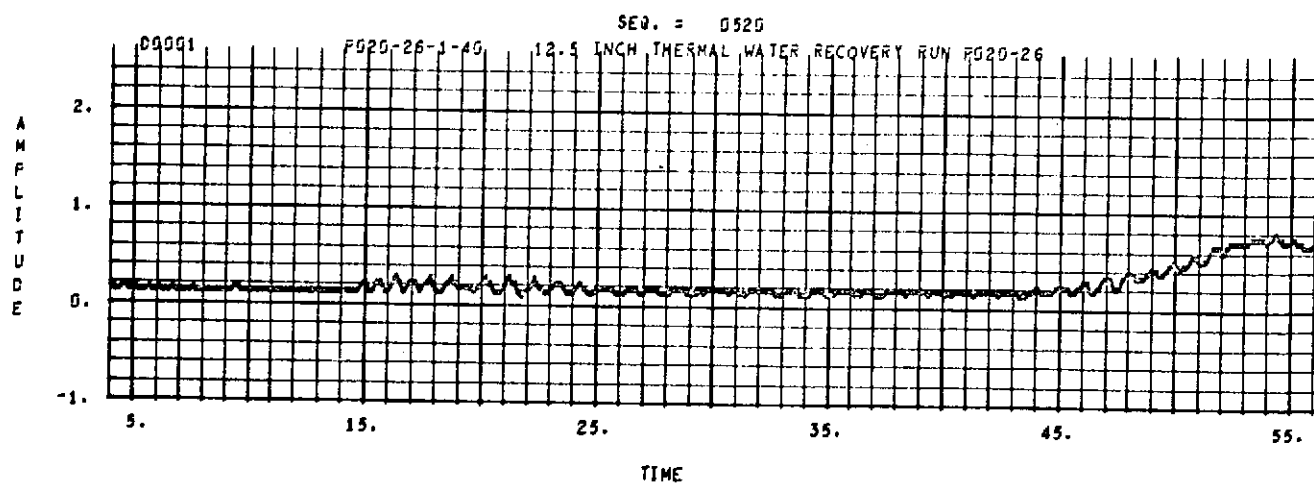
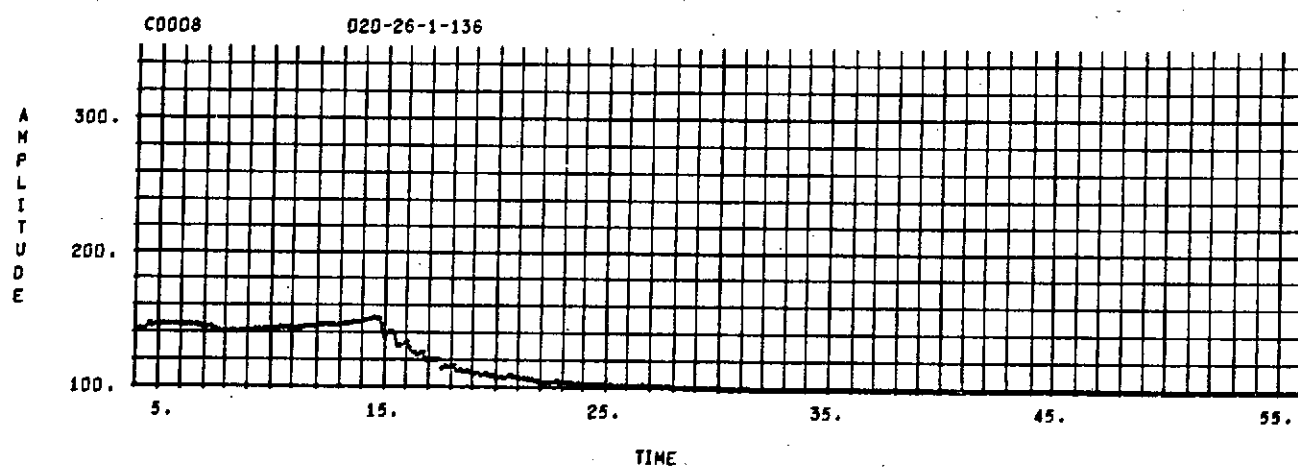
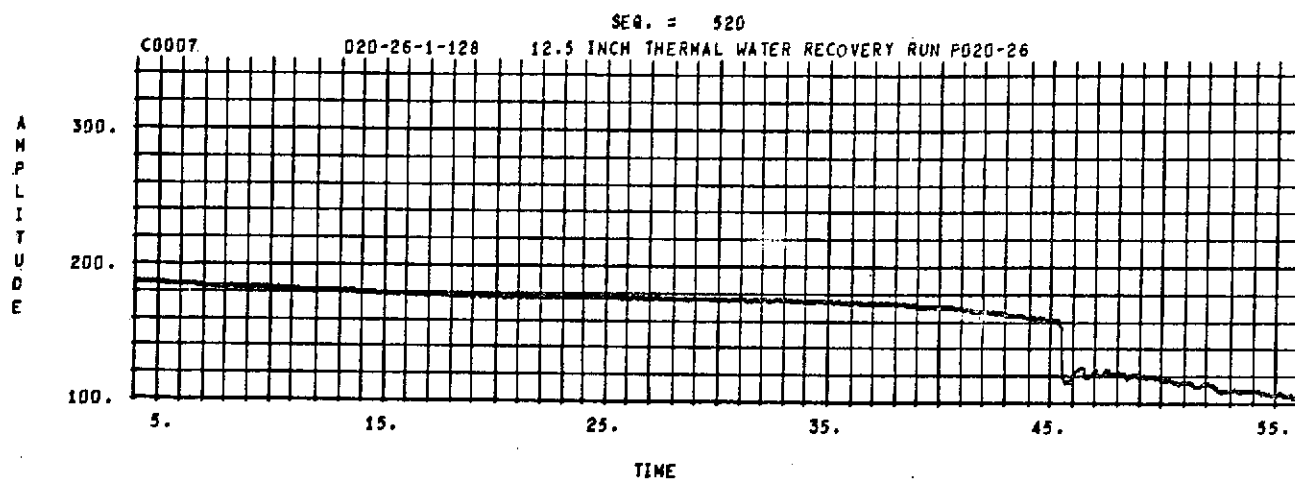
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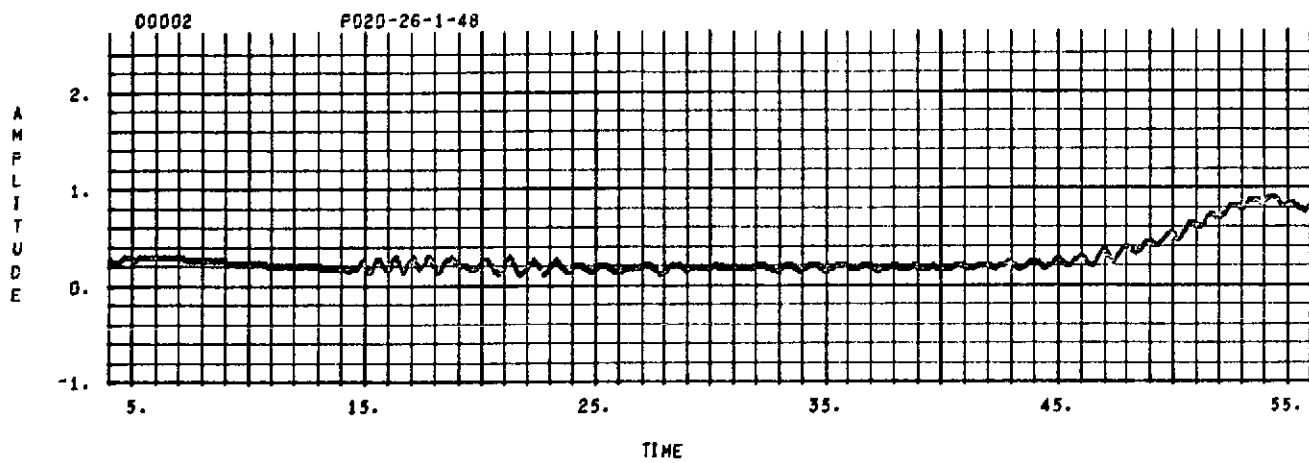
P020-26-1-48

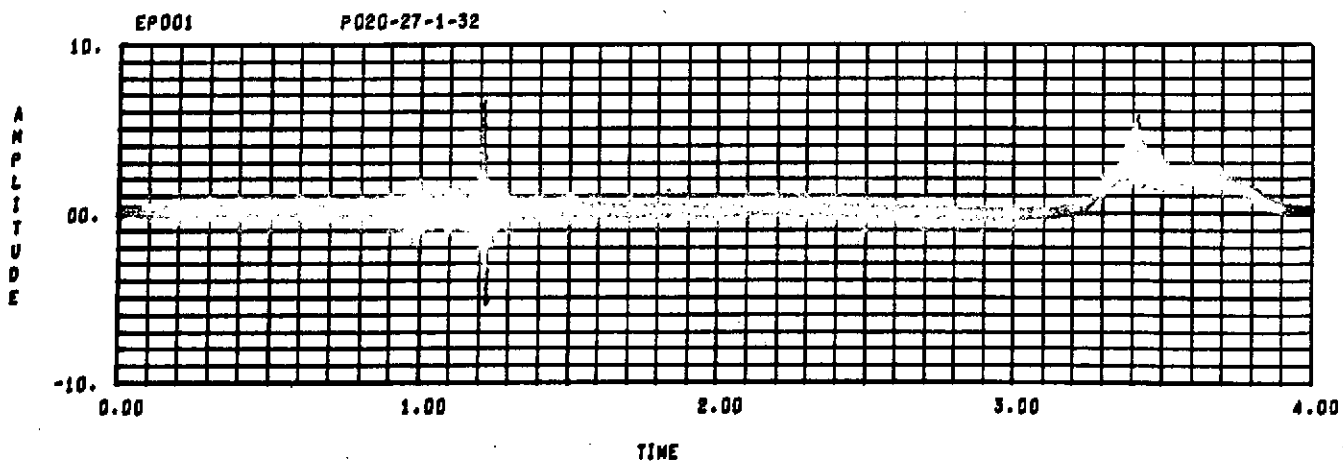
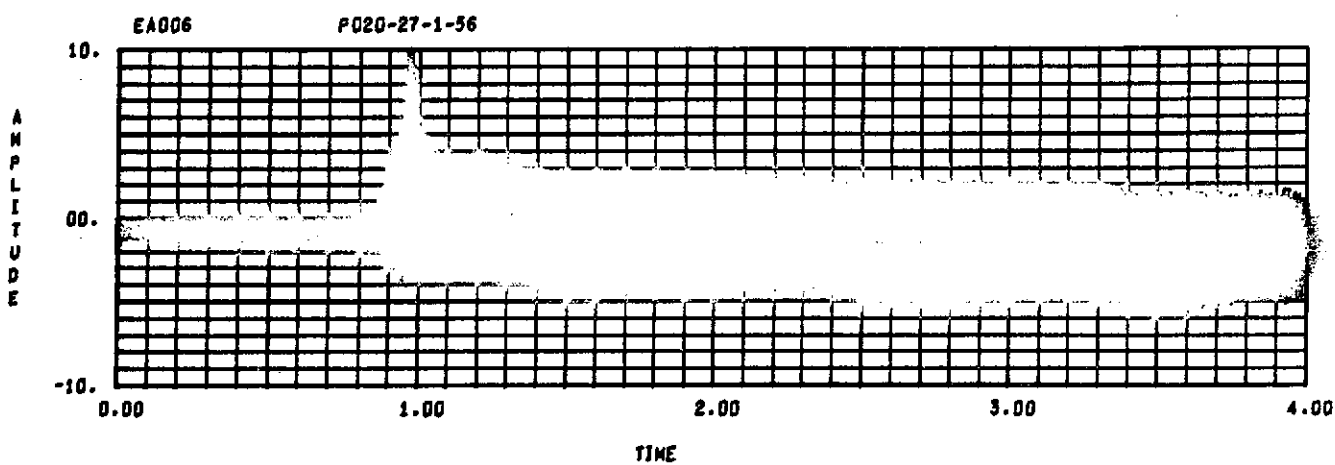
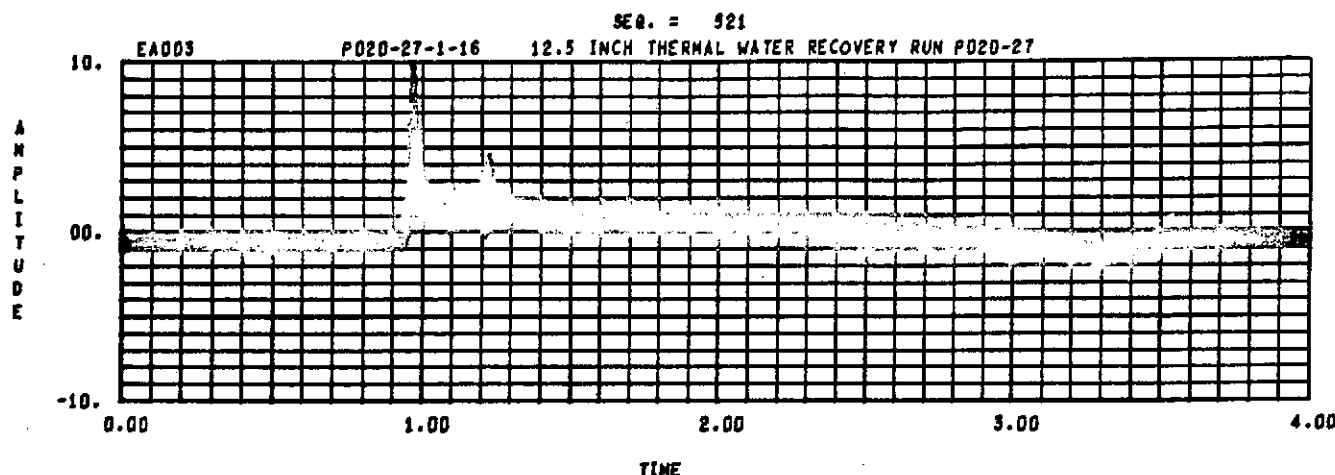




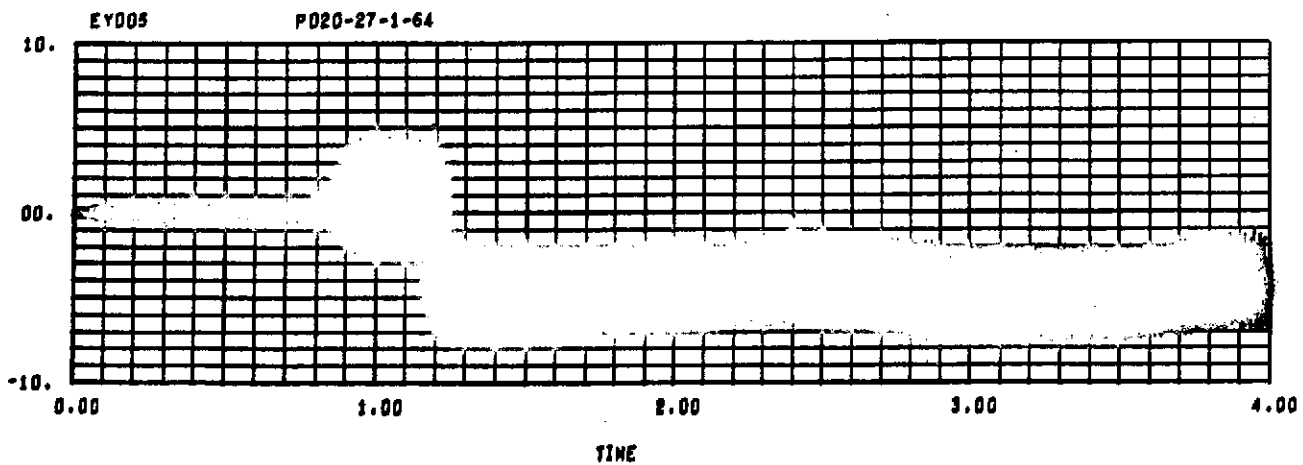
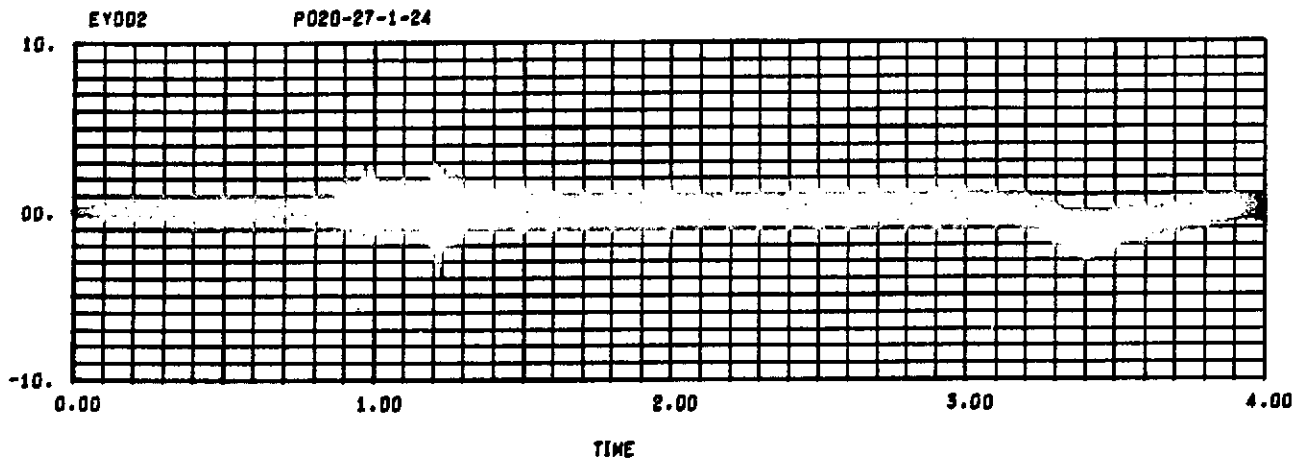
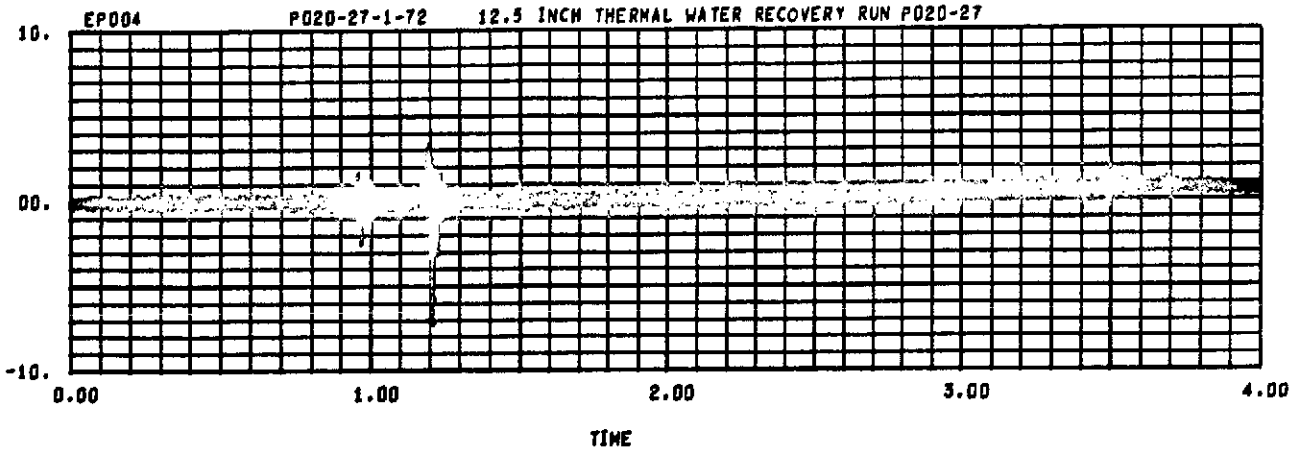


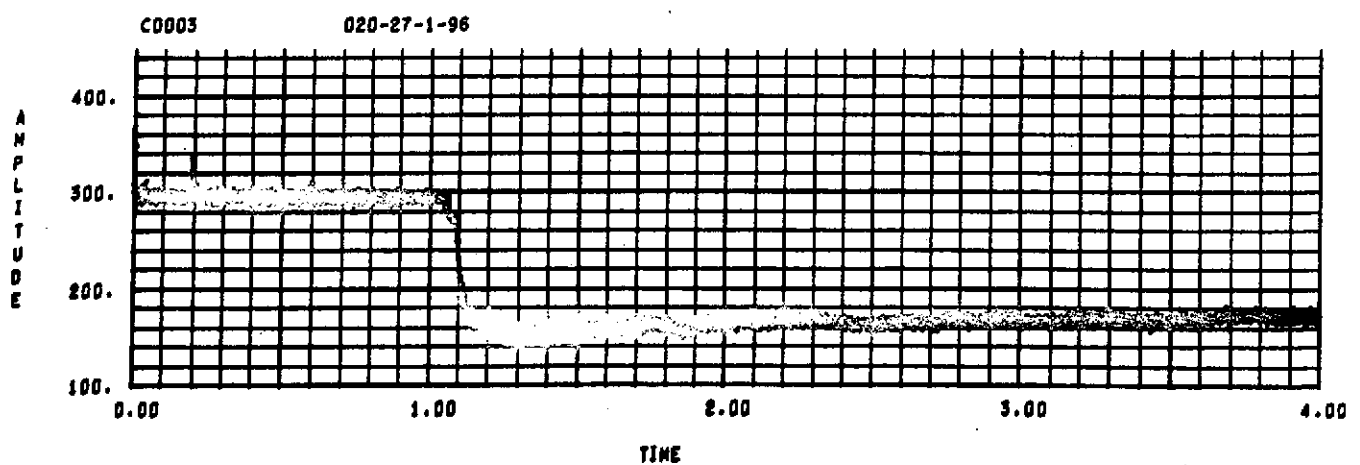
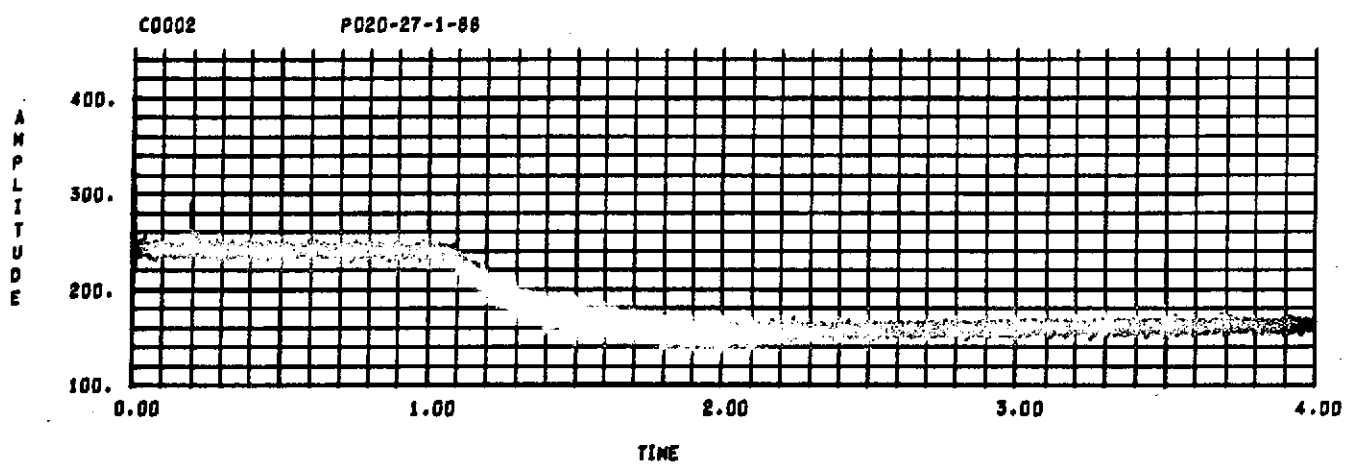
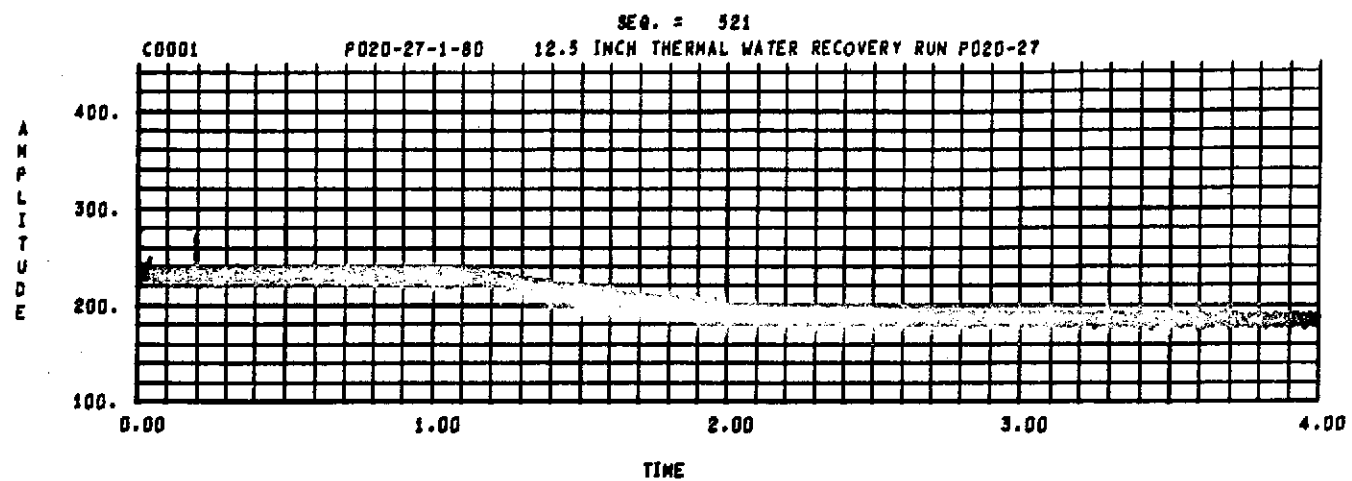


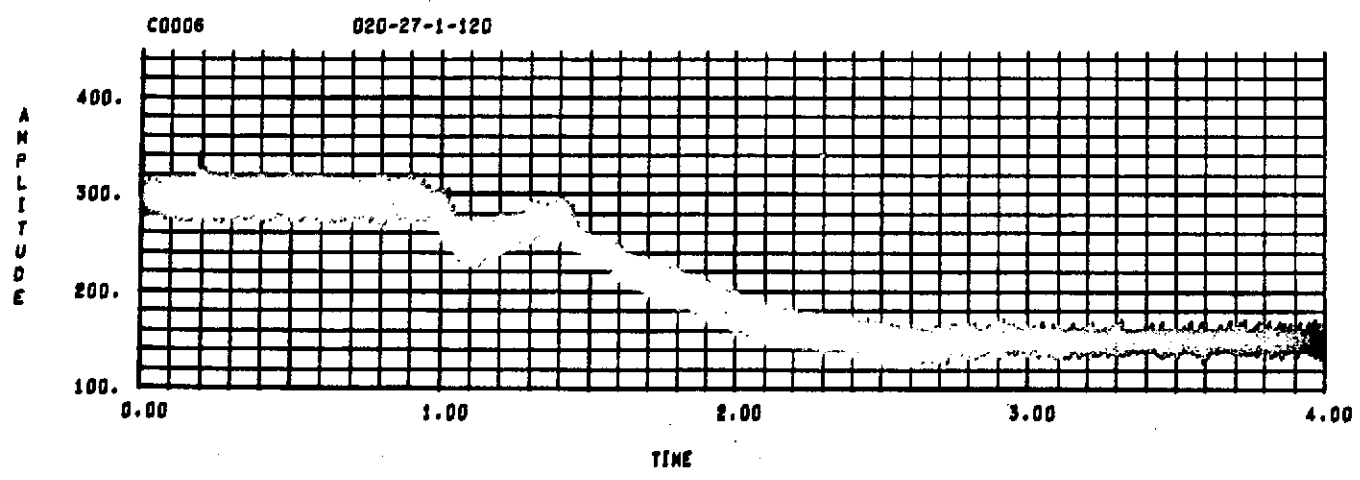
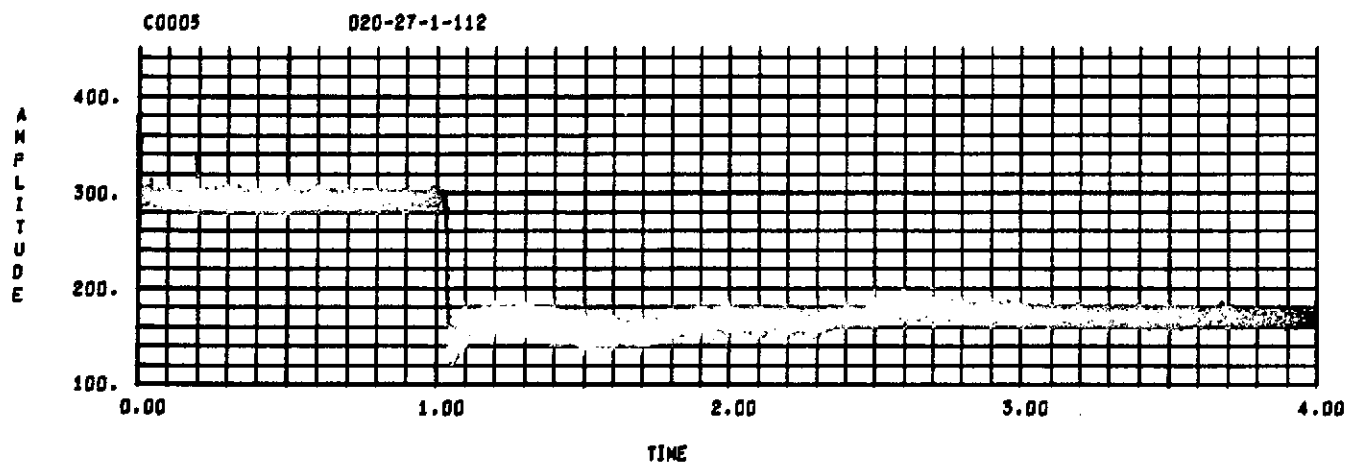
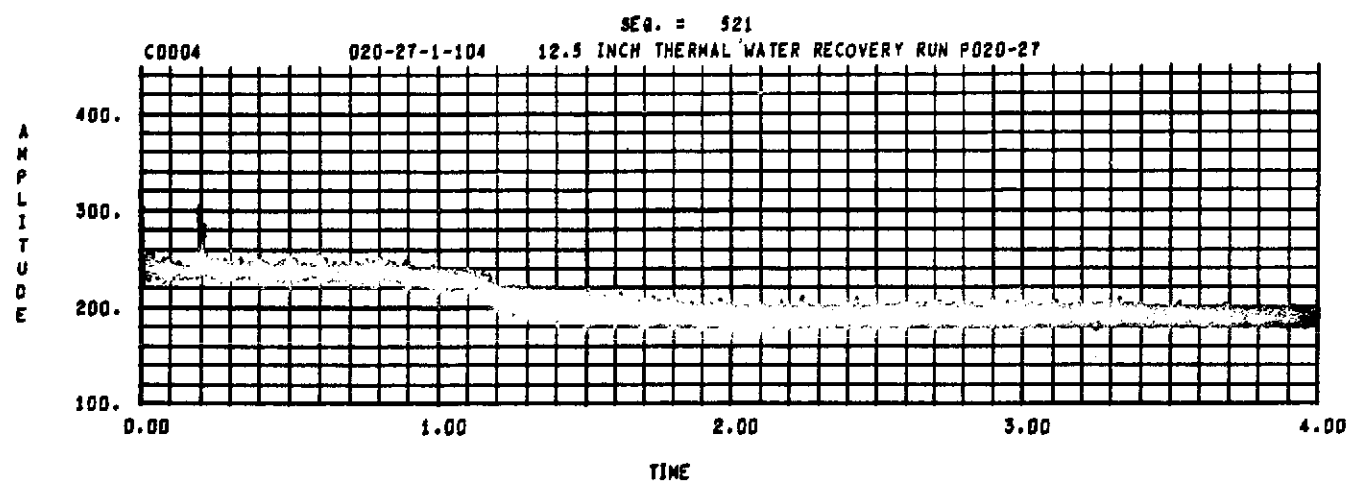


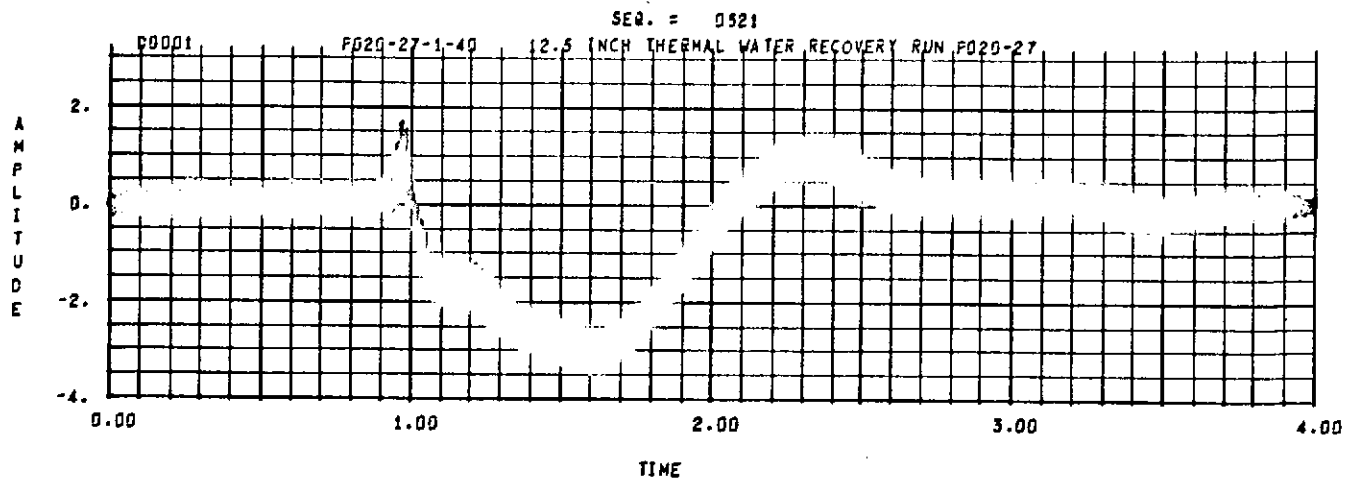
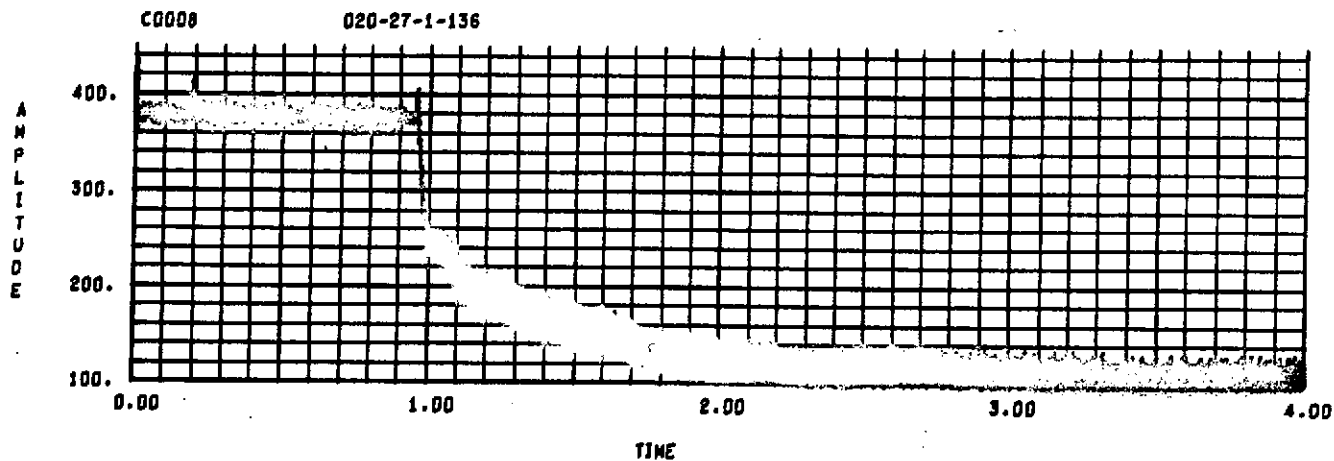
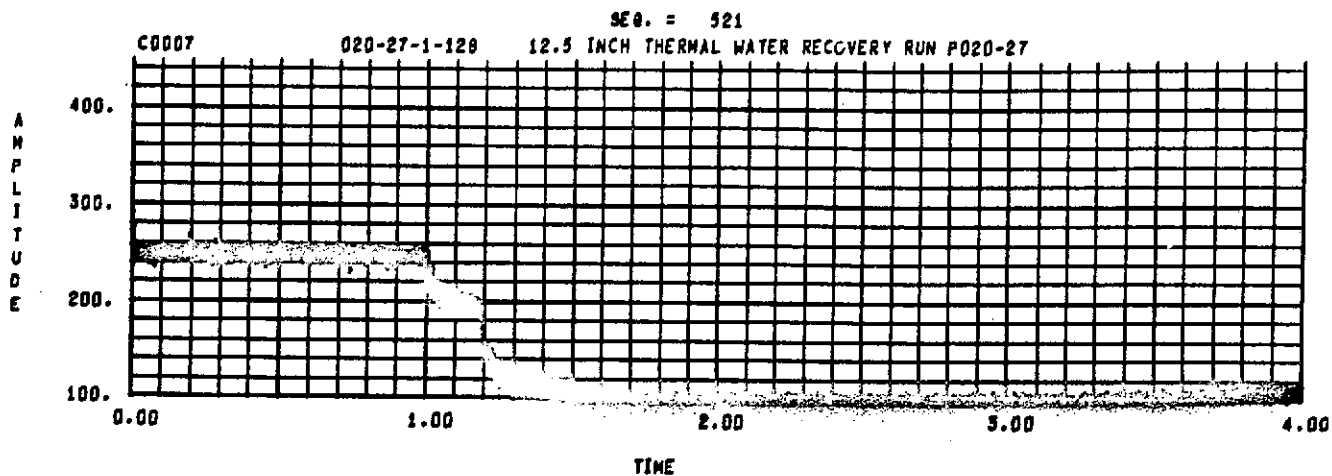


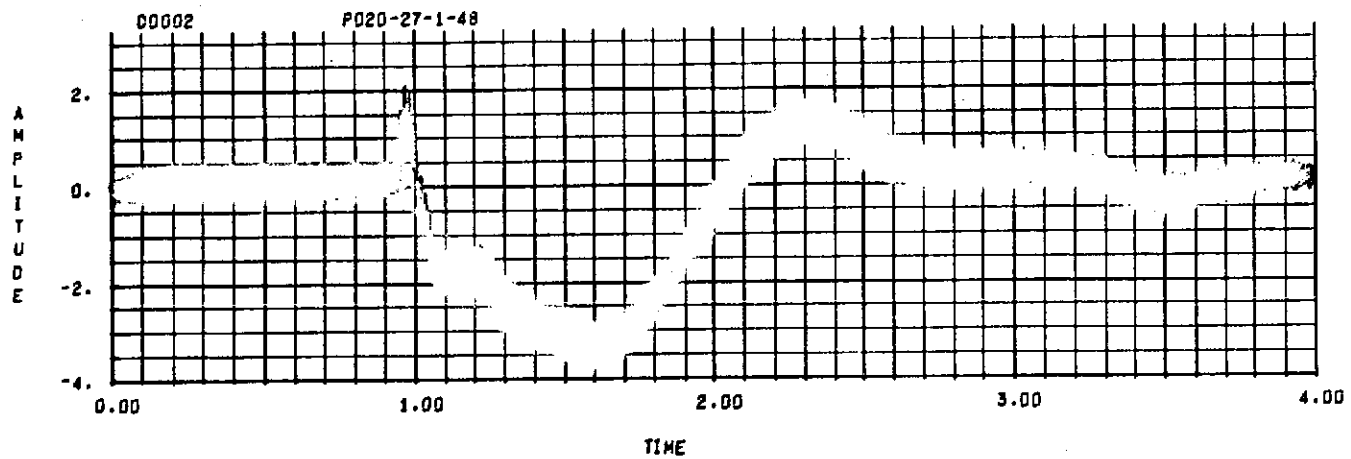
SEQ. = 521

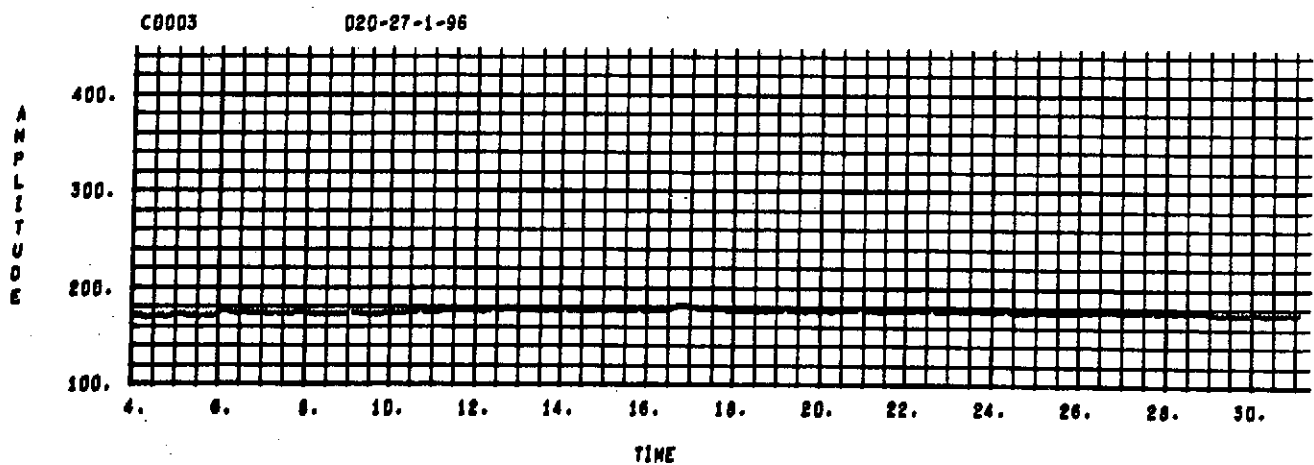
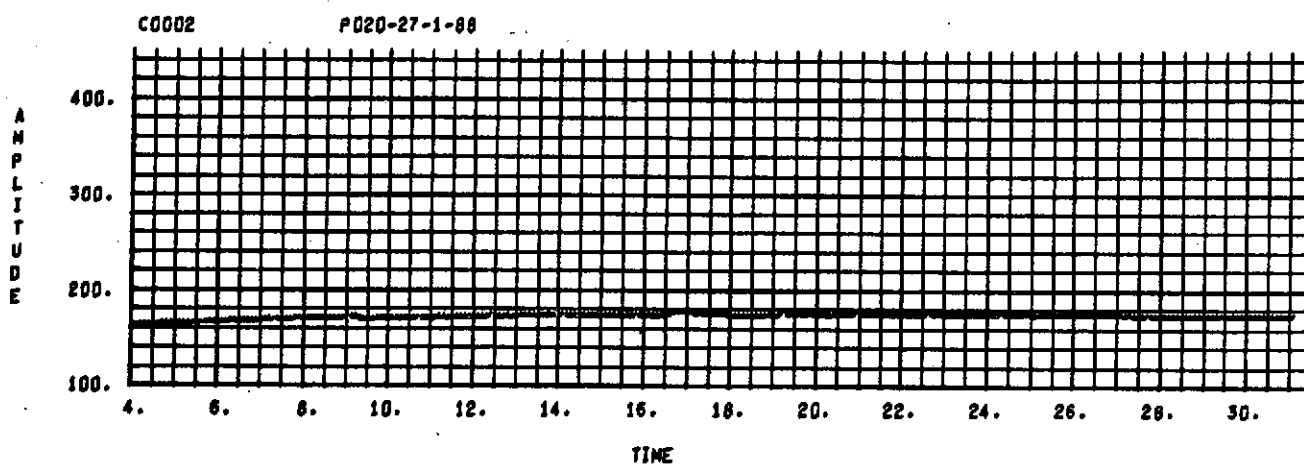
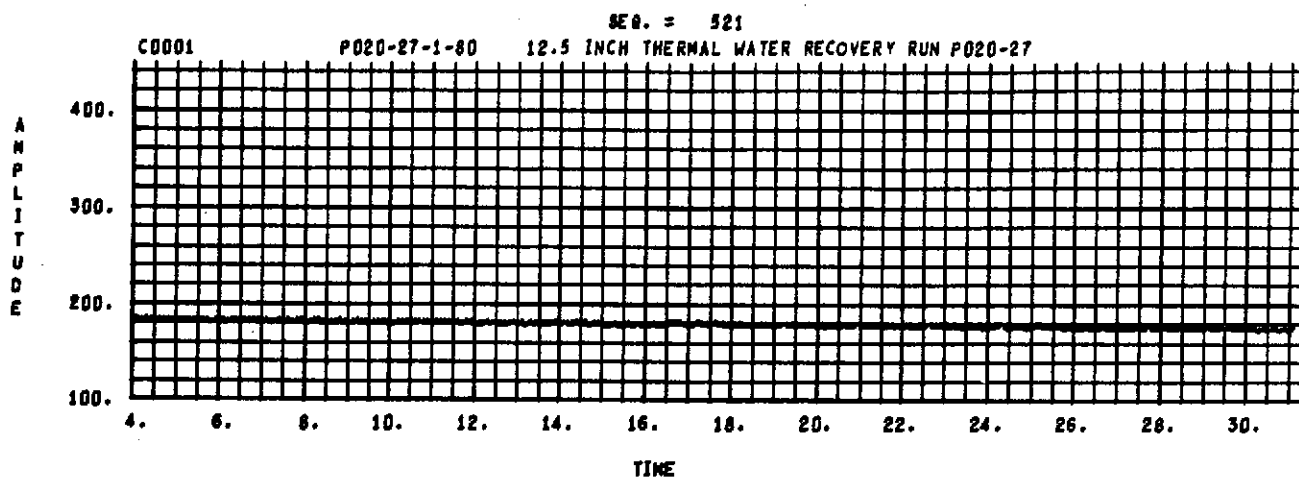


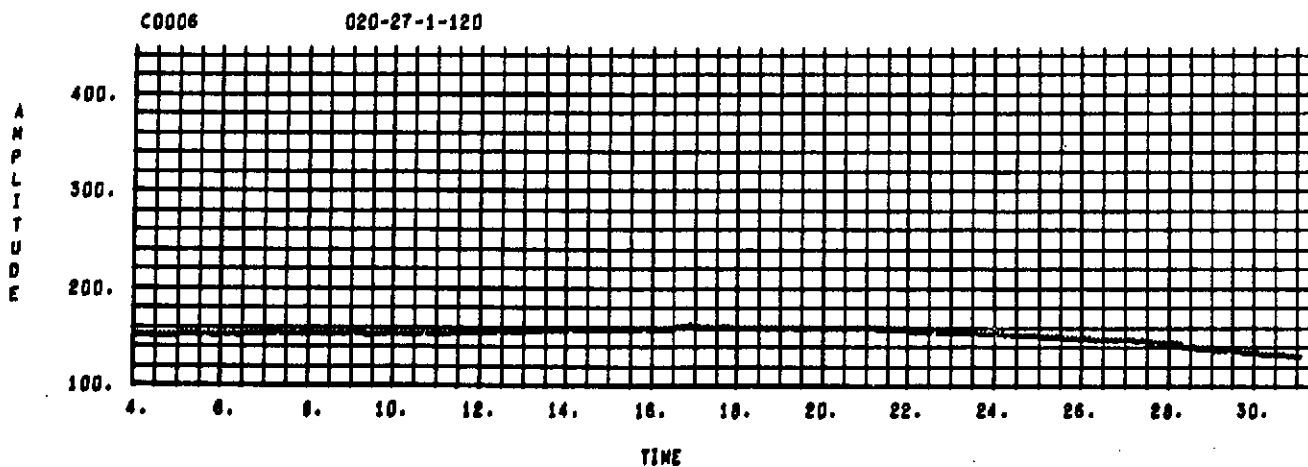
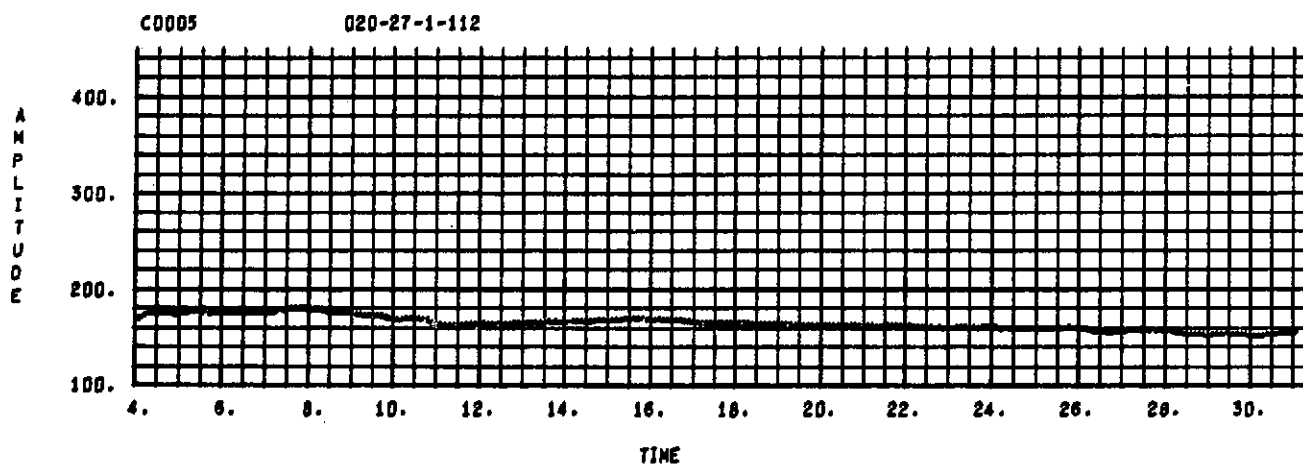
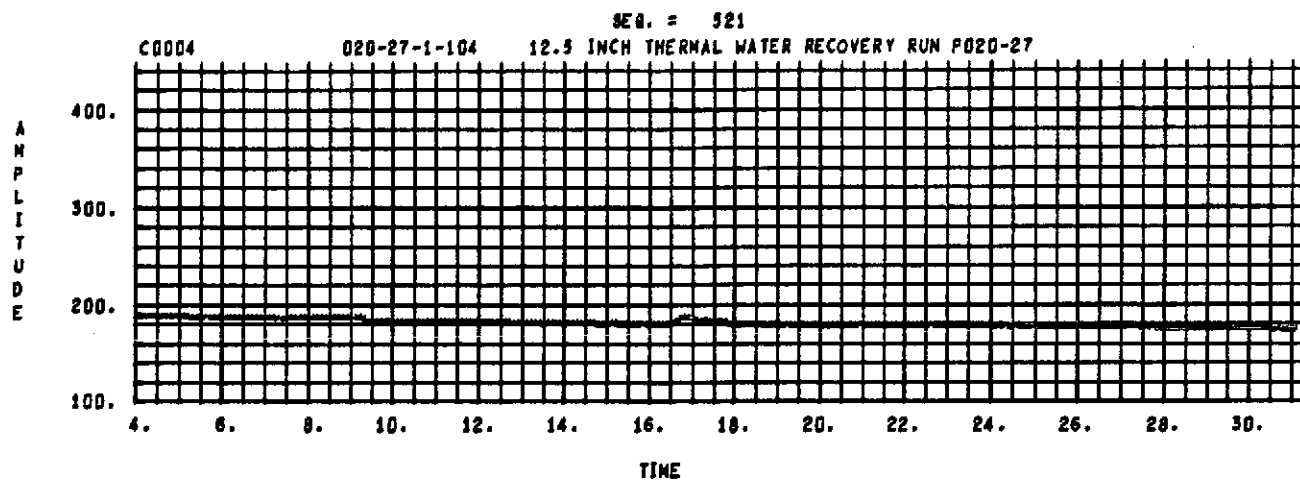


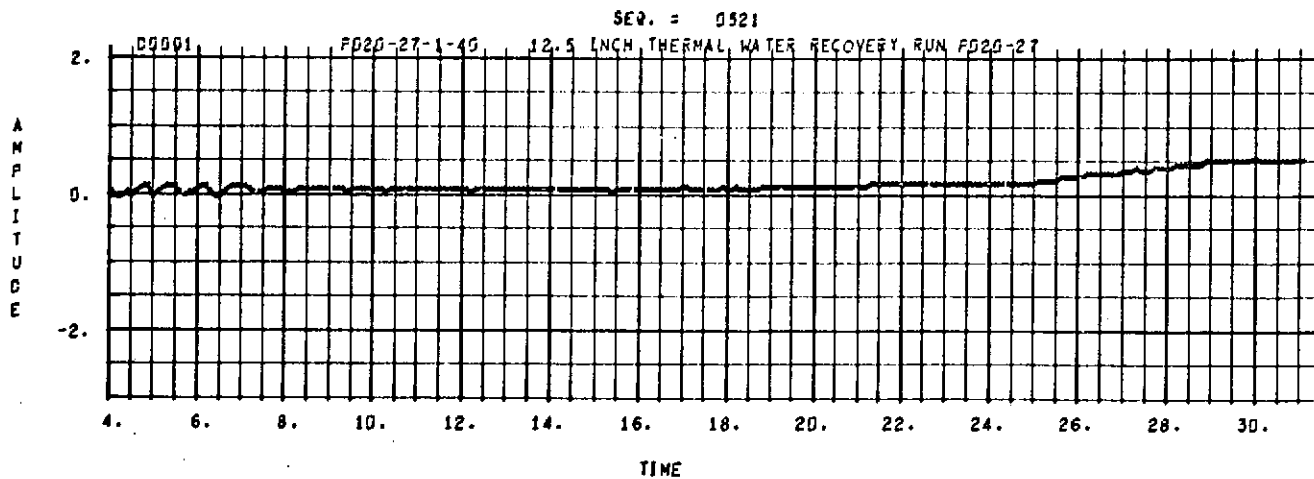
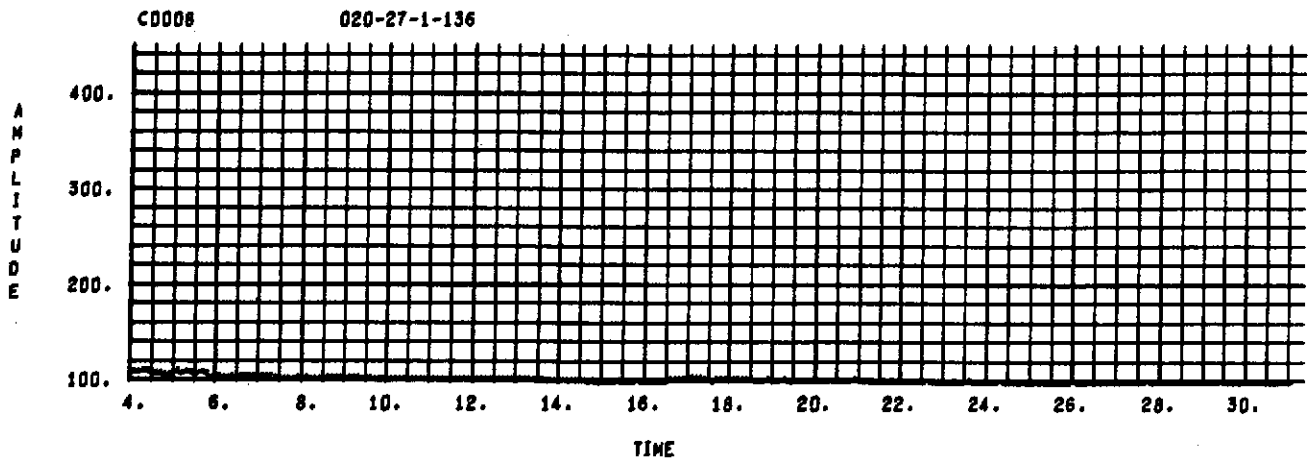
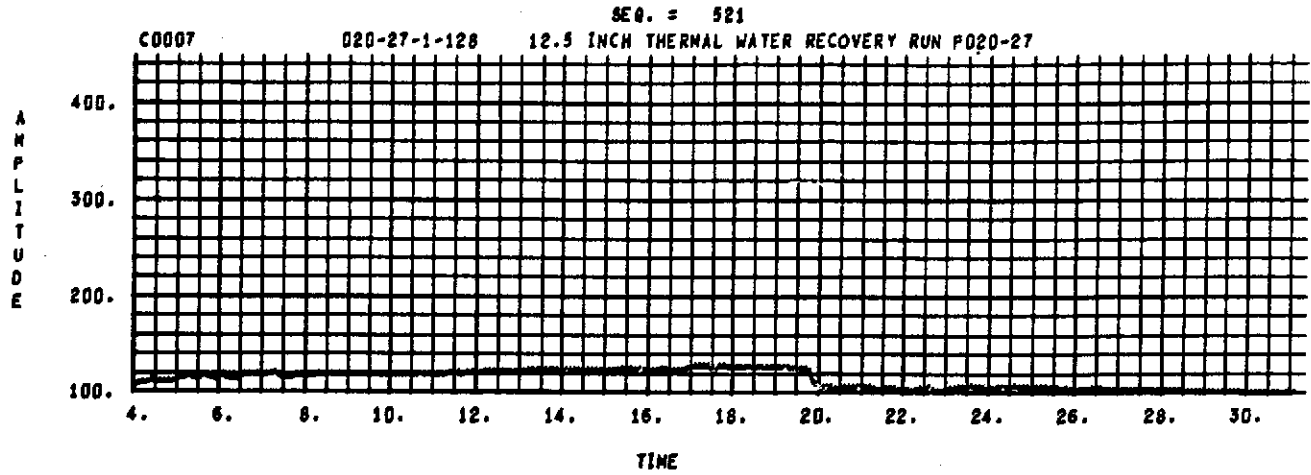


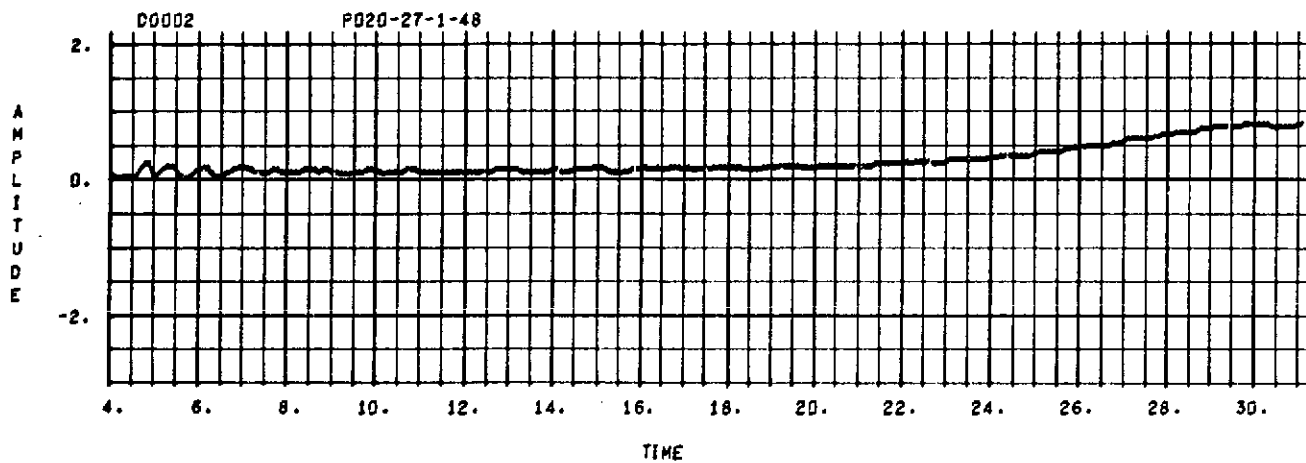


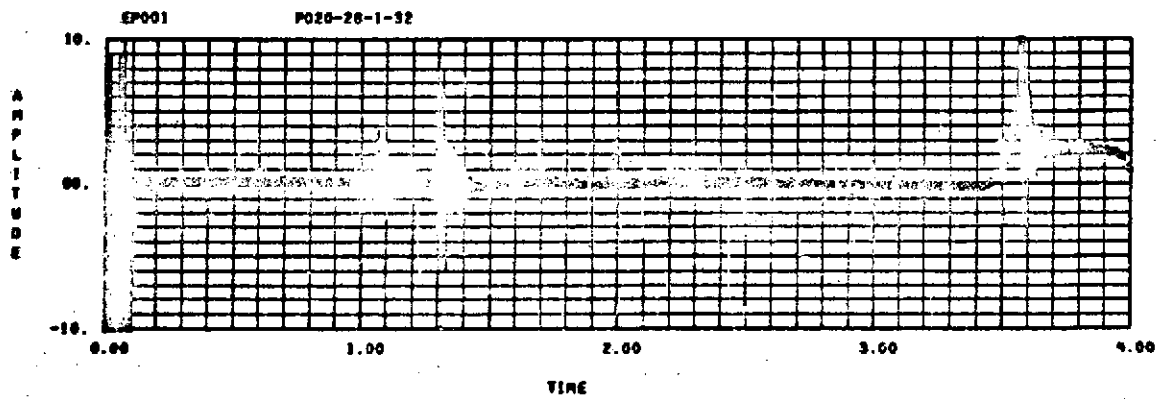
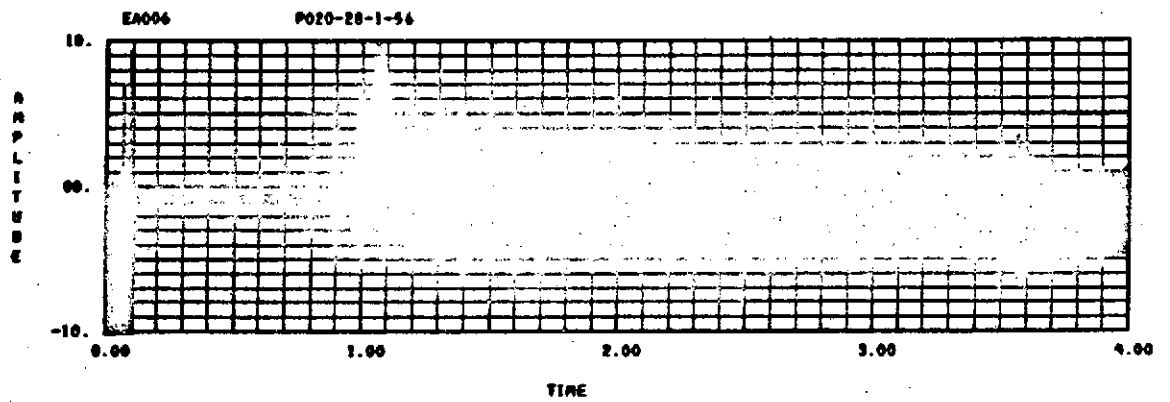
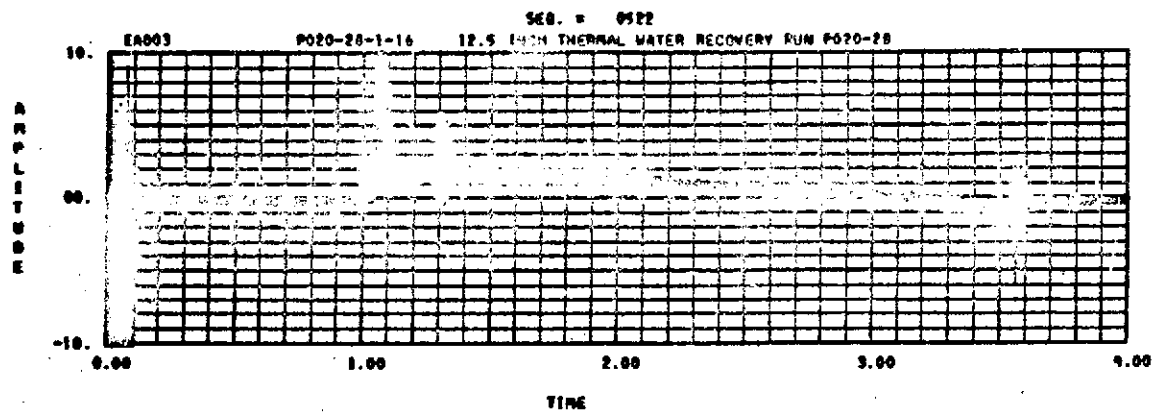






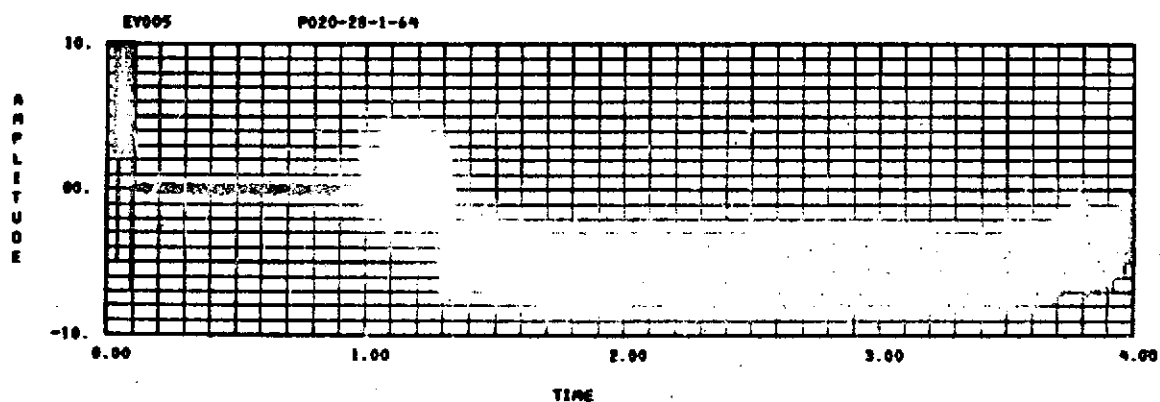
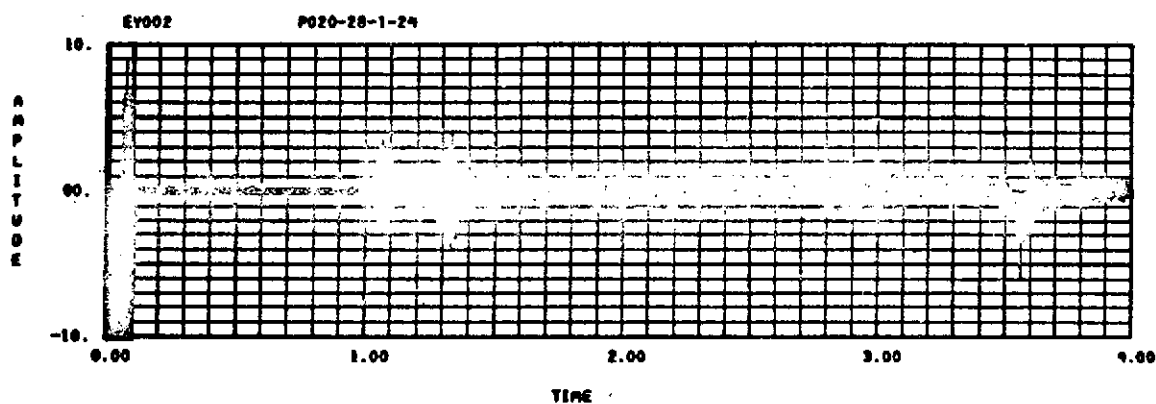
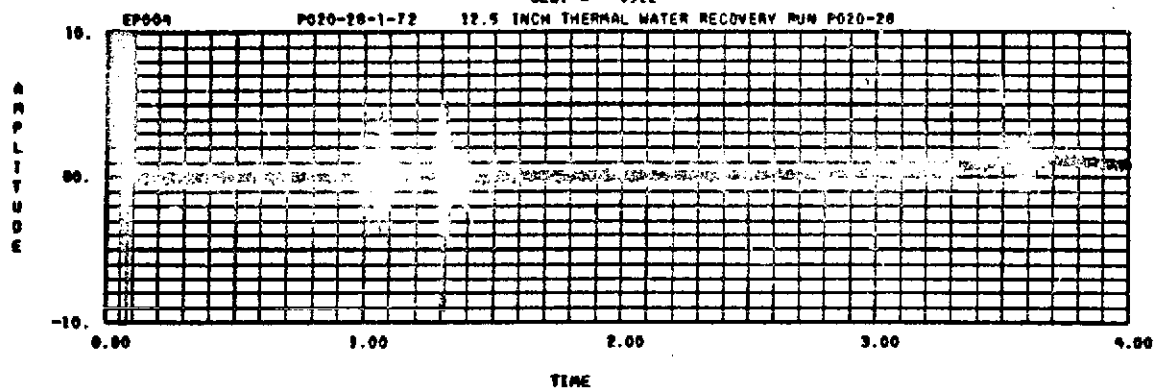


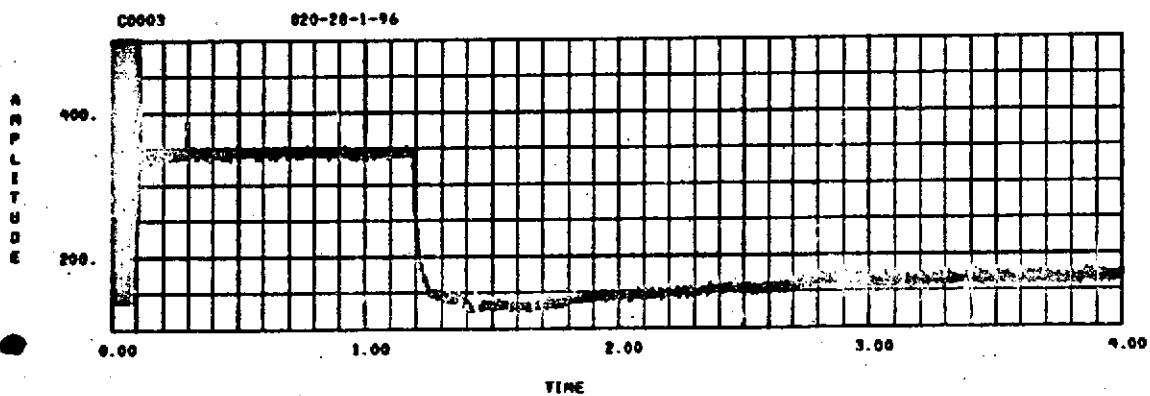
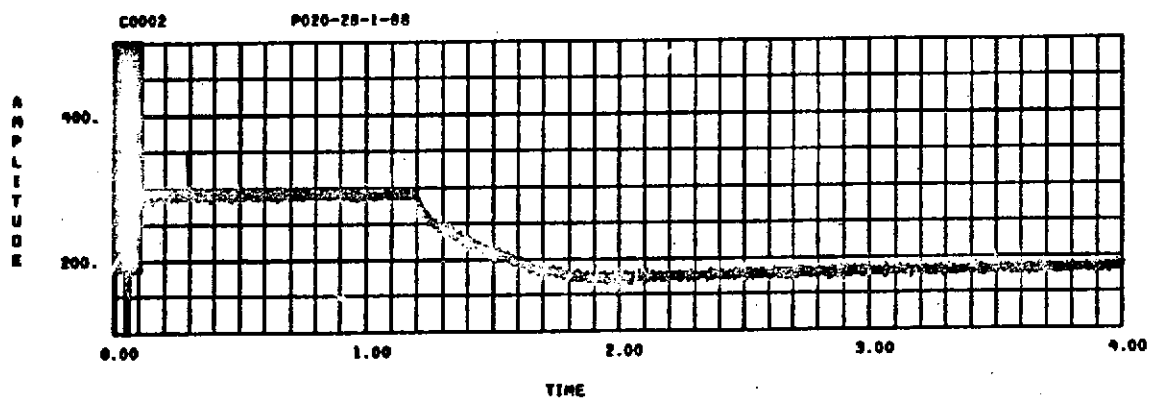
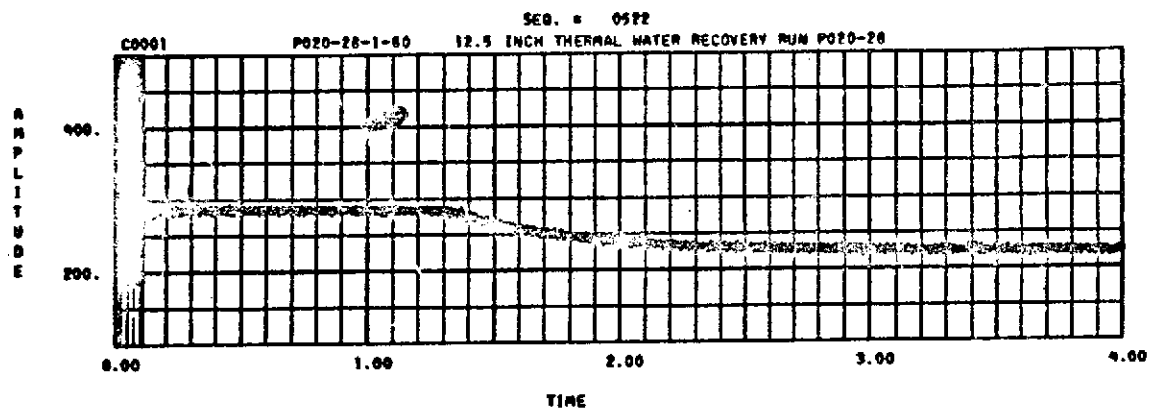


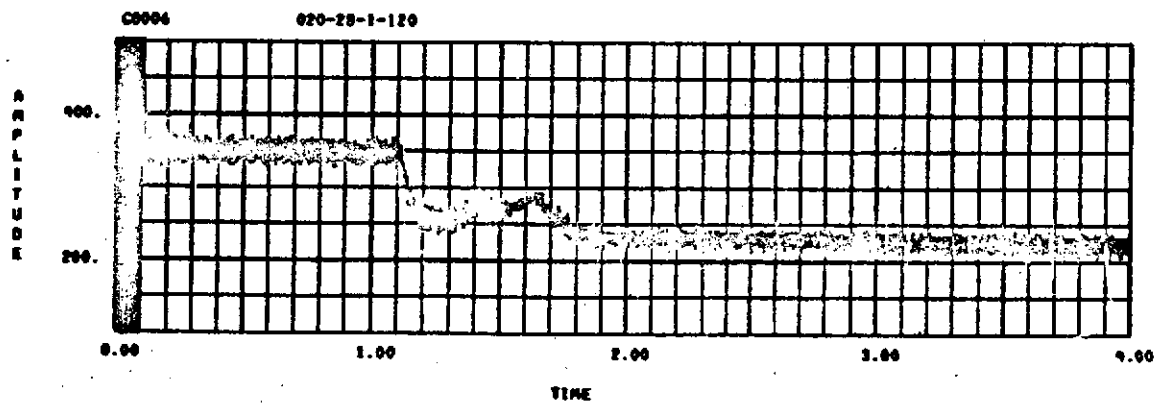
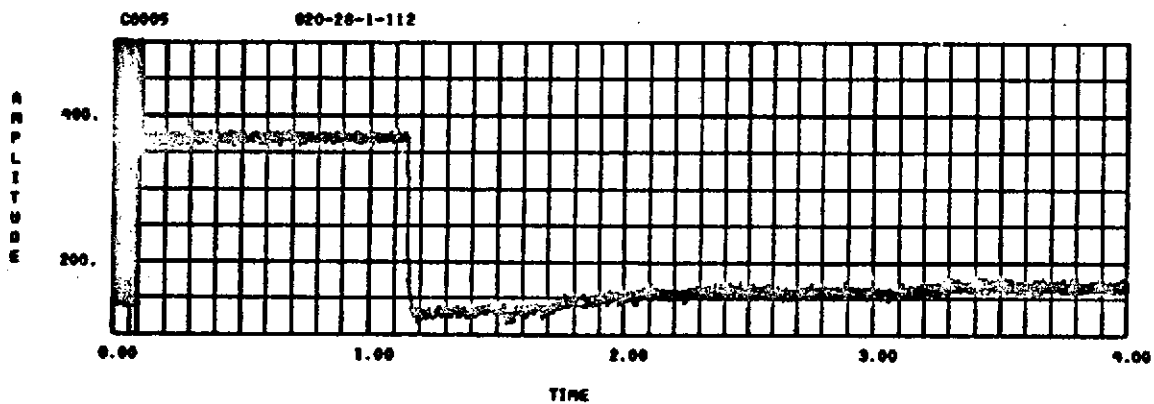
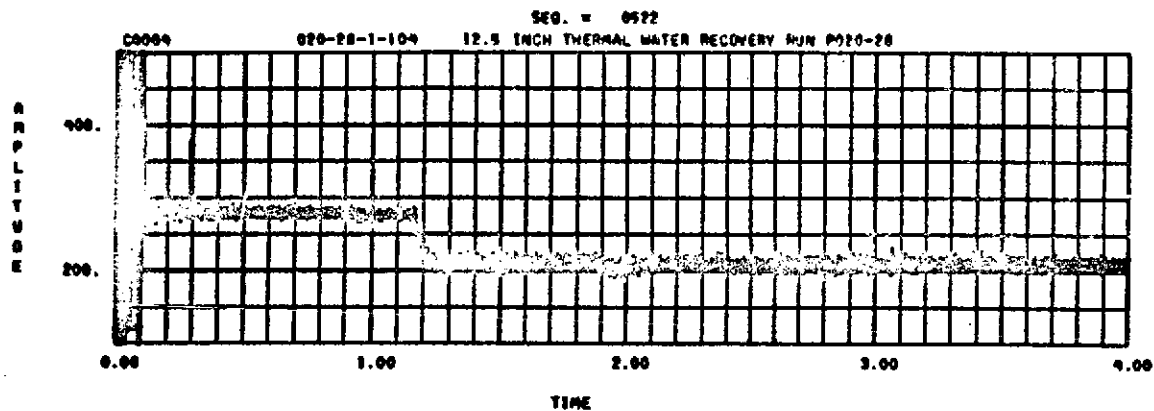


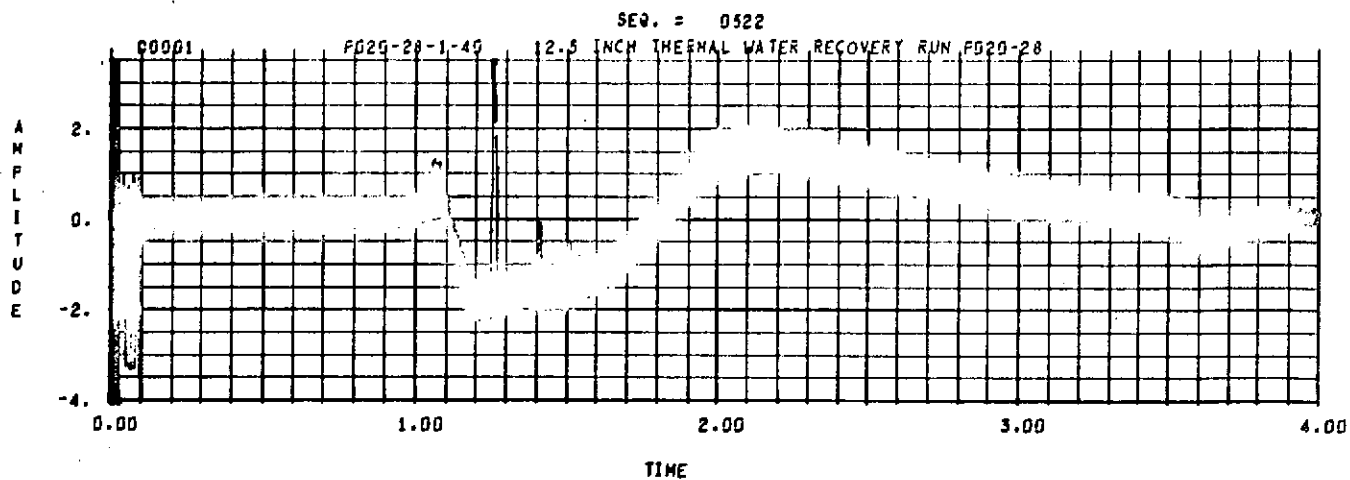
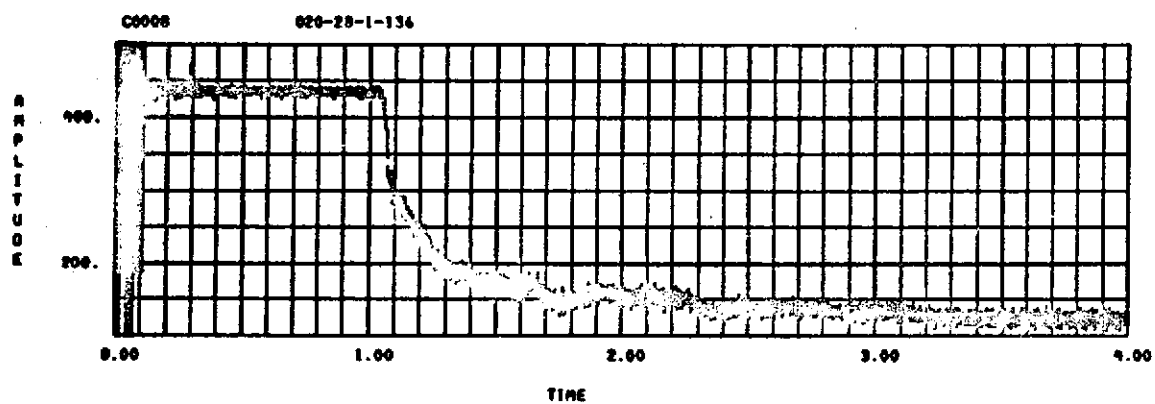
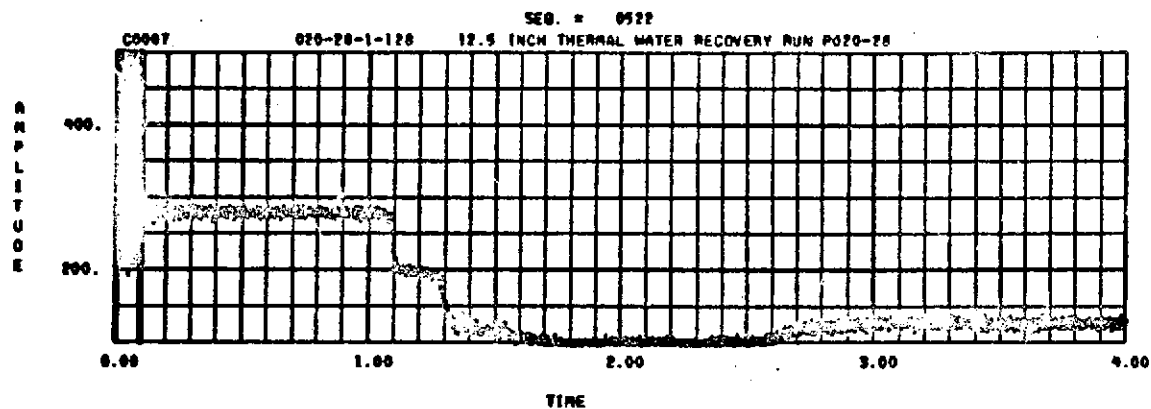
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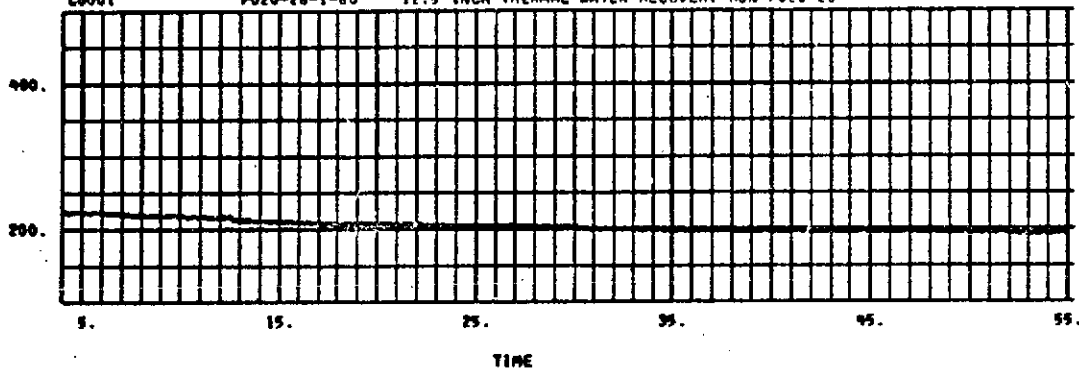


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11

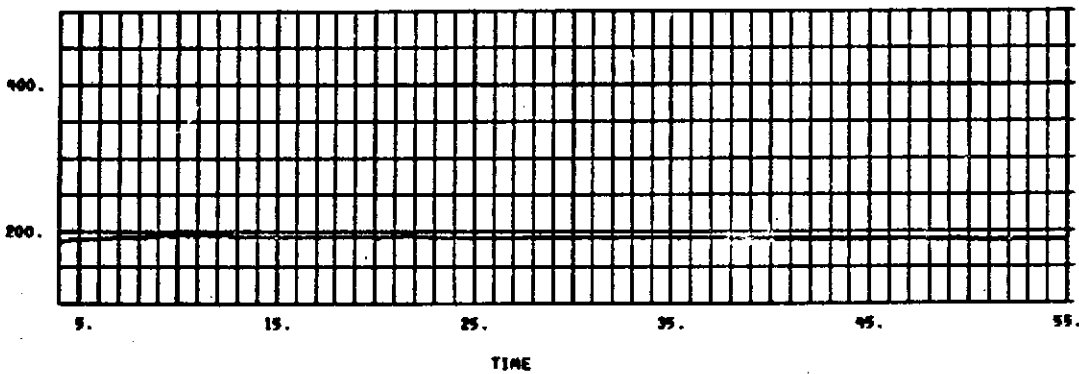
C0001 P020-28-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-29

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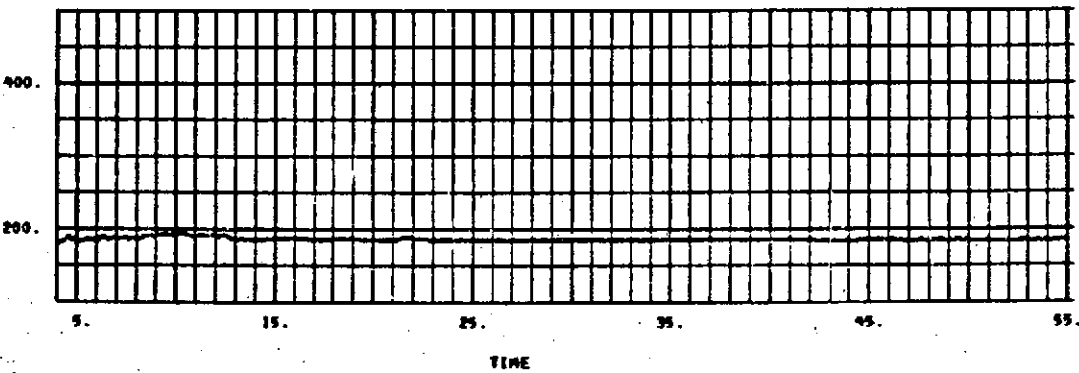
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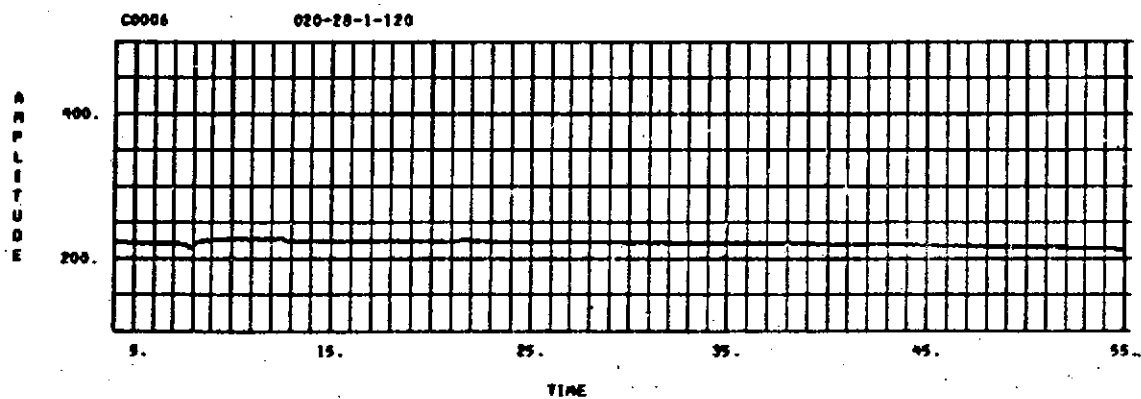
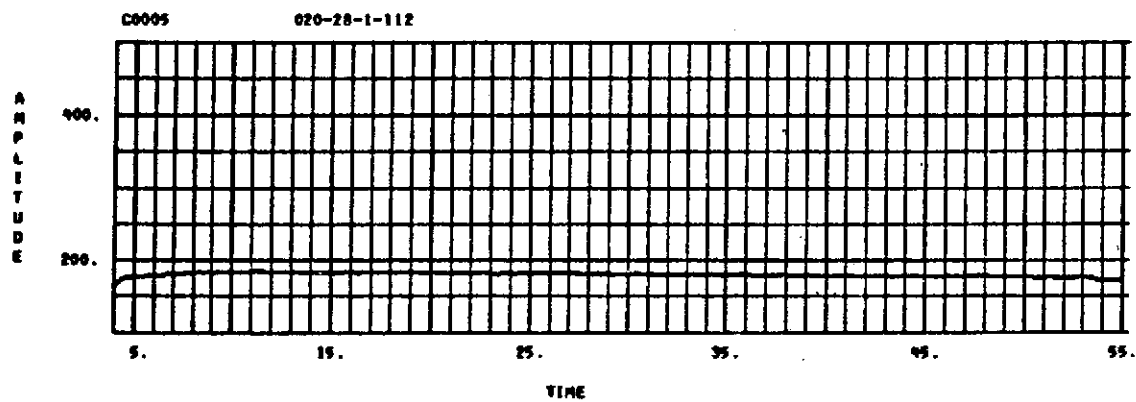
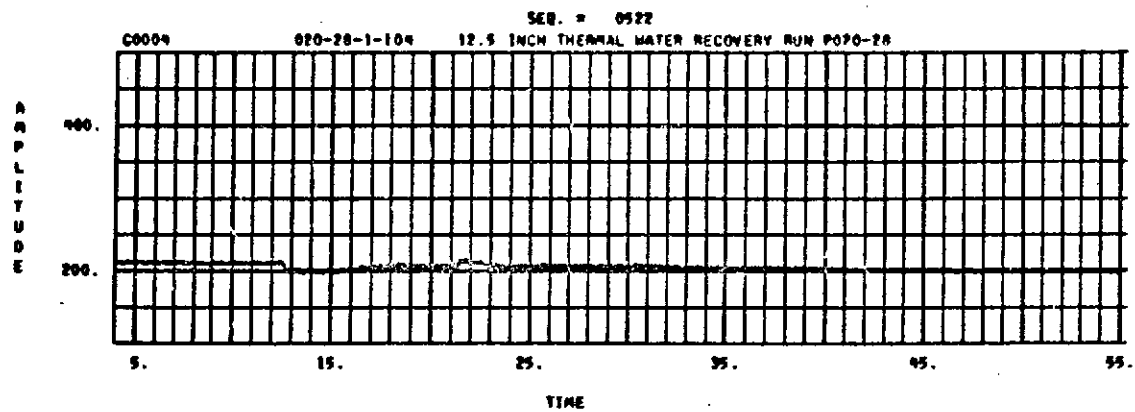
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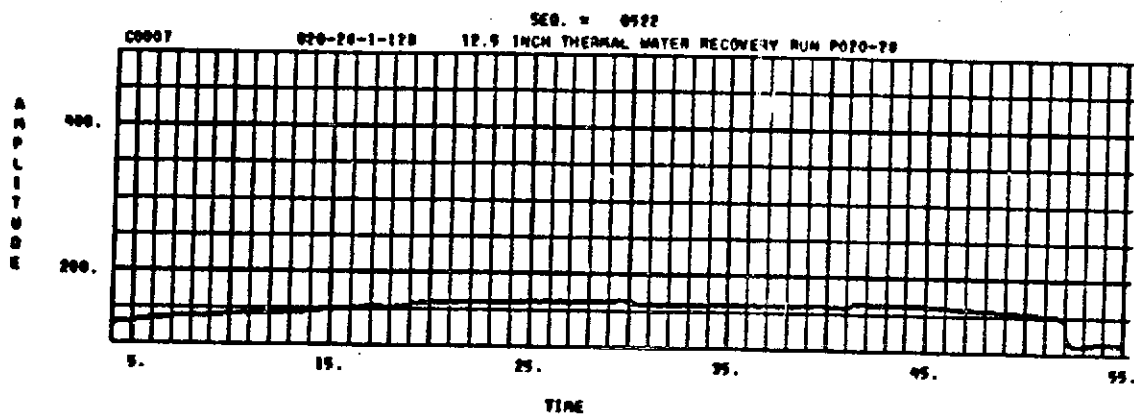


C0003 020-28-1-96

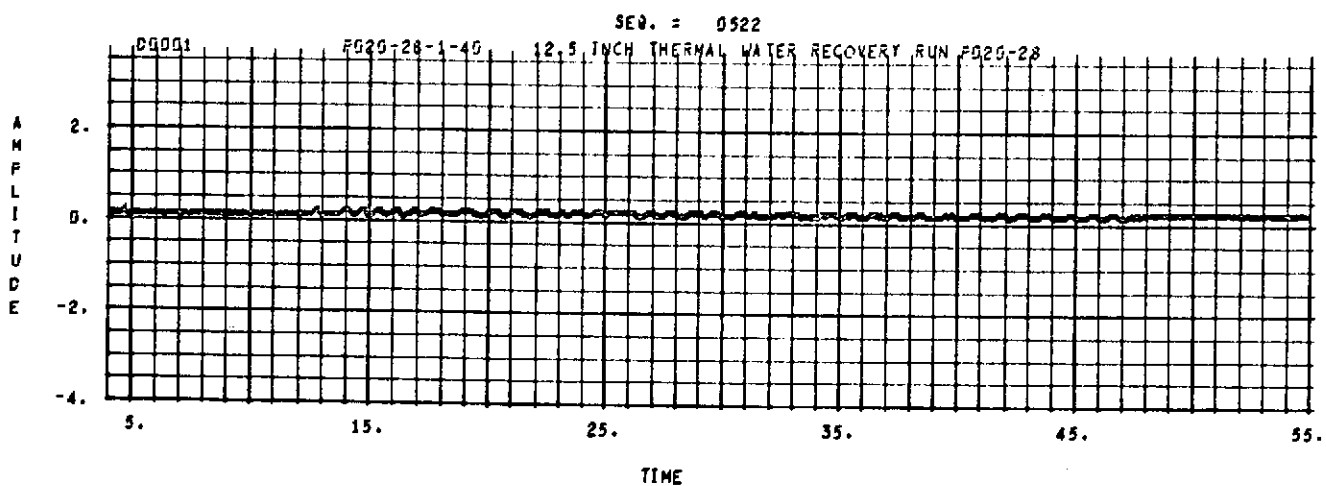
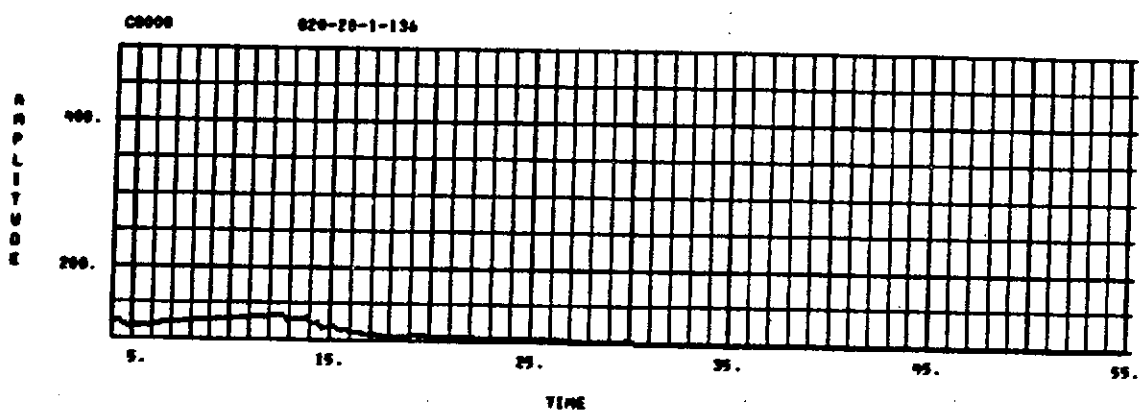
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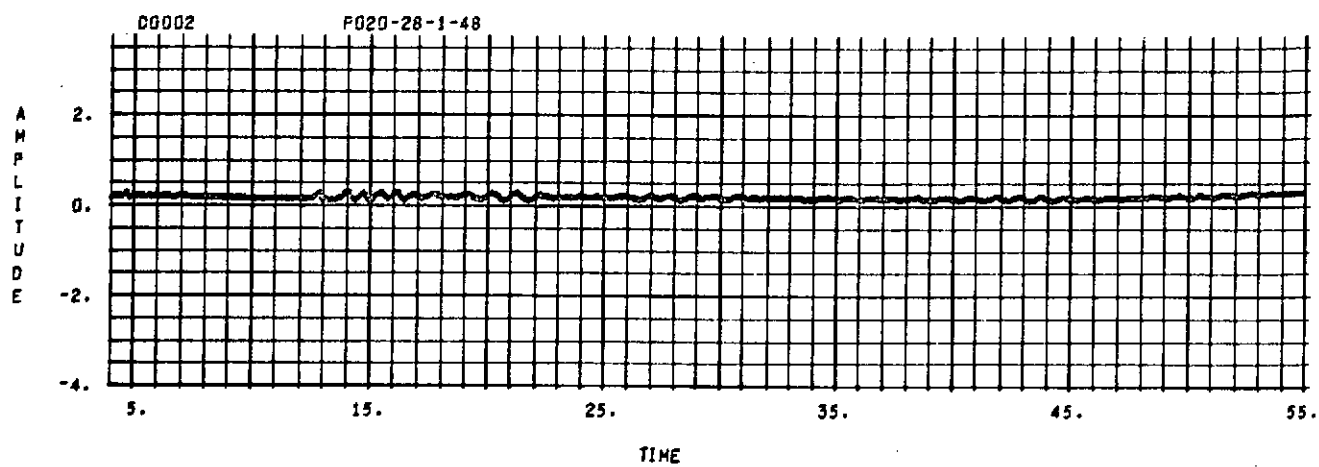


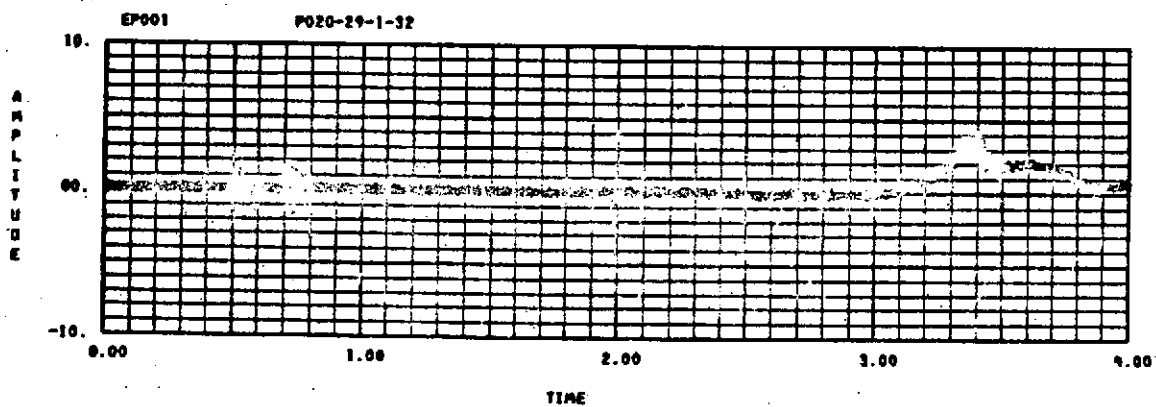
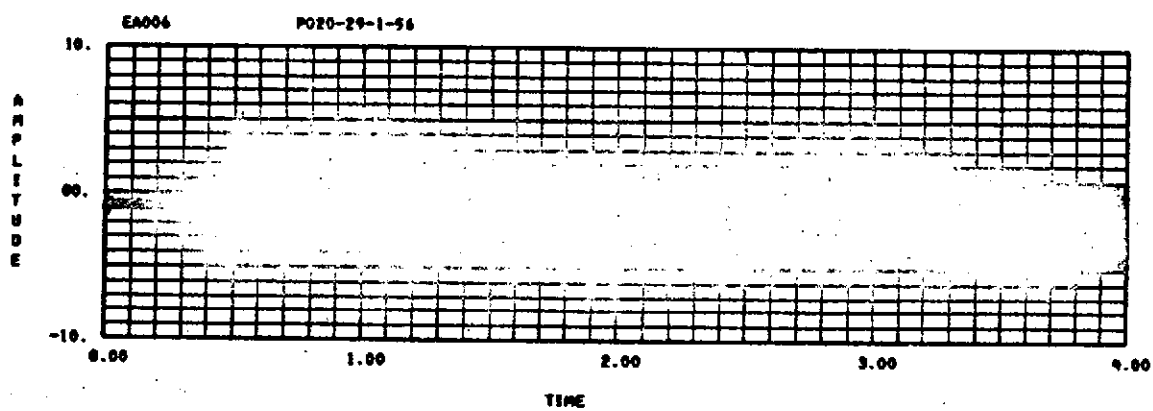
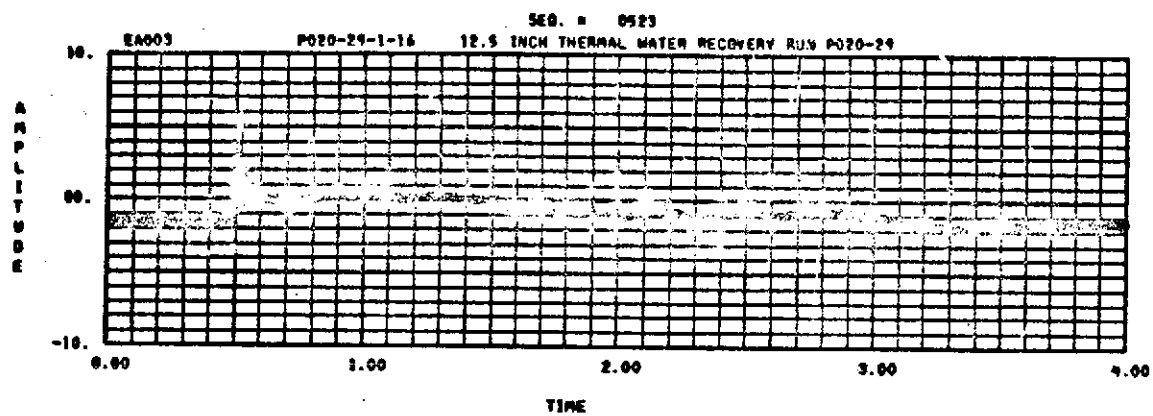


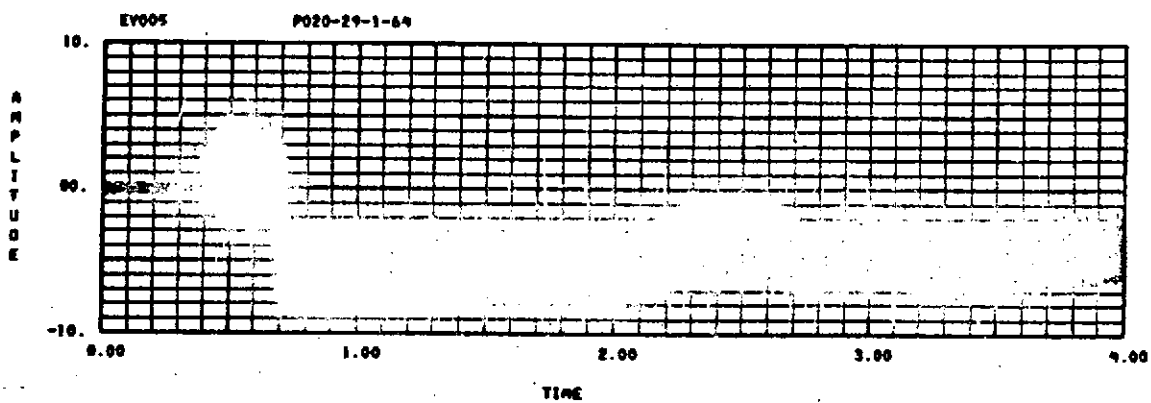
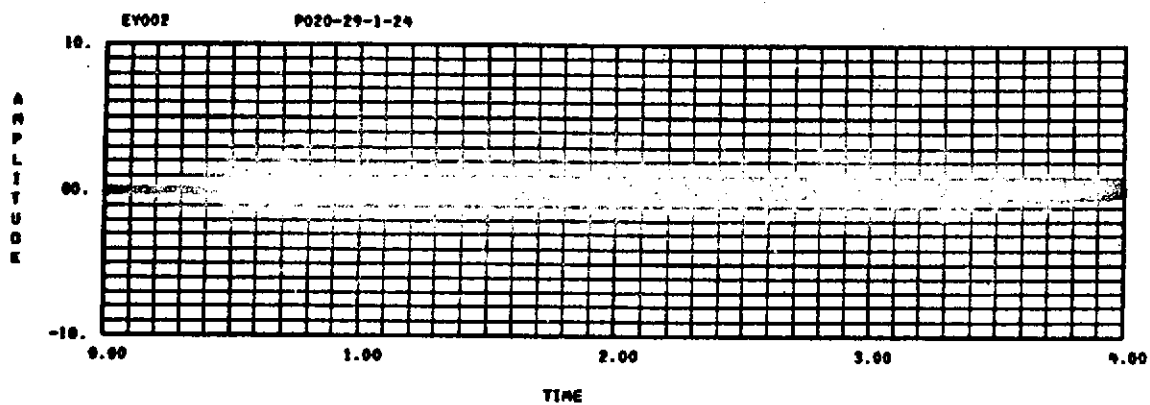
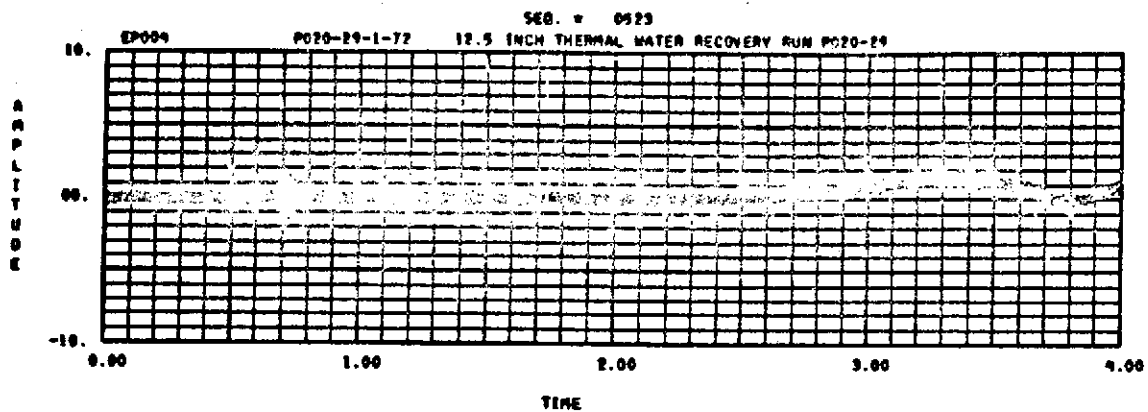
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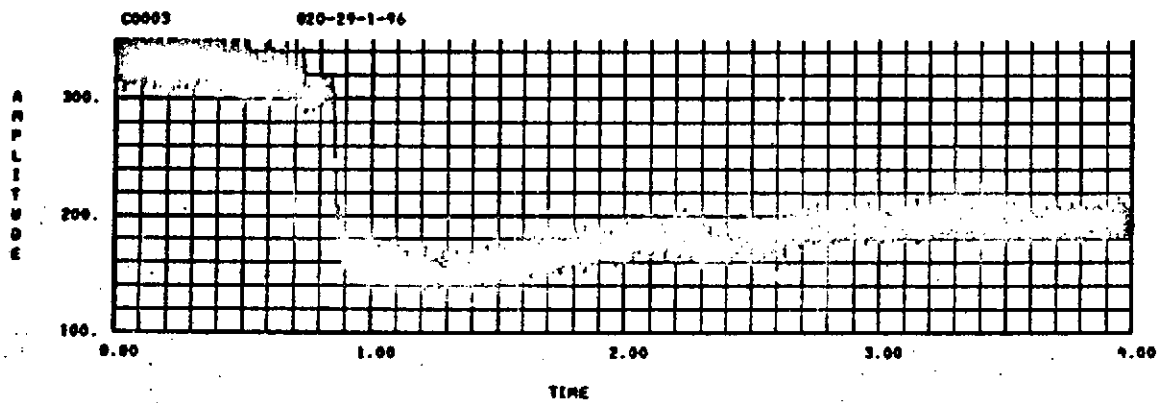
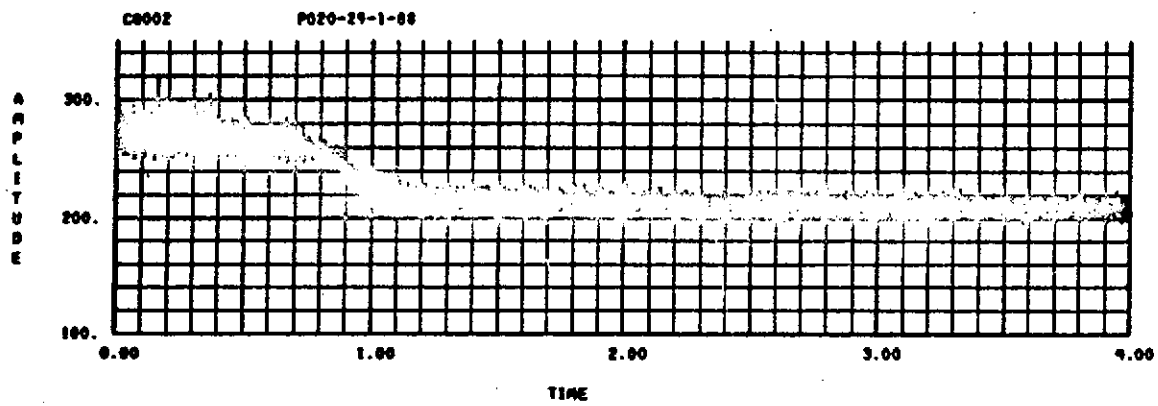
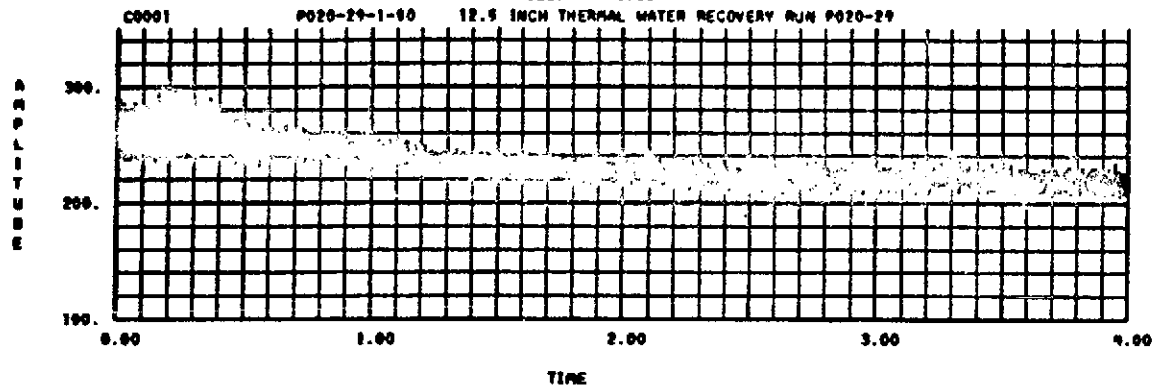


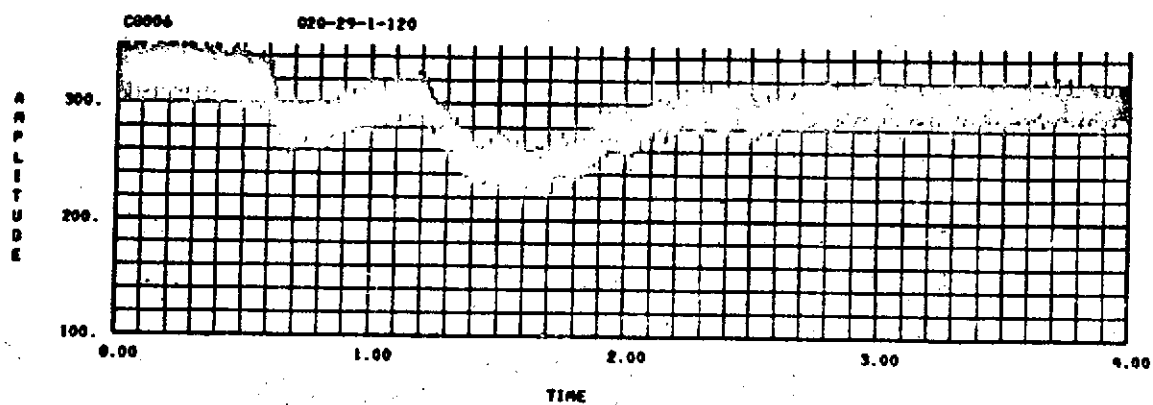
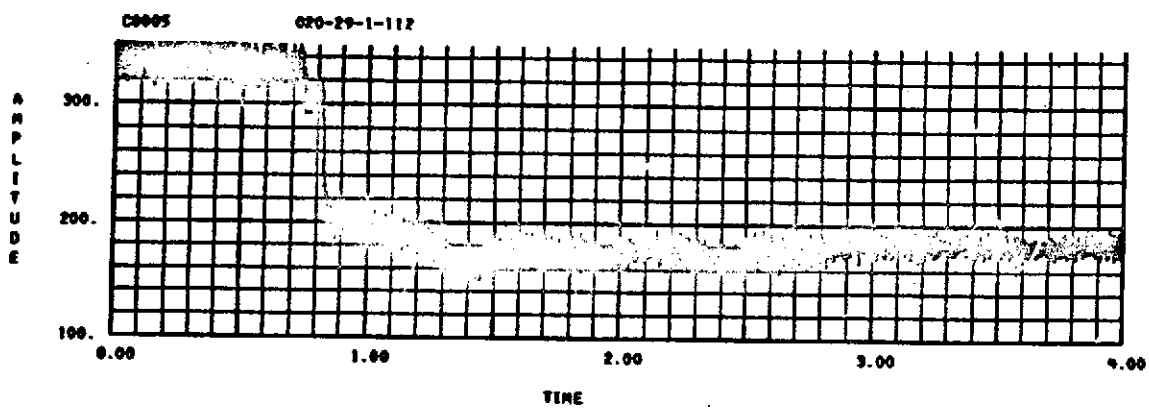
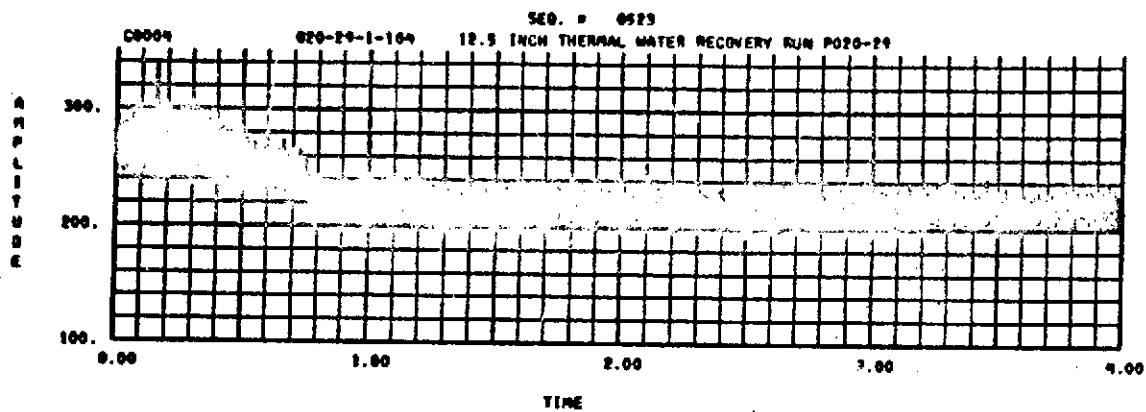


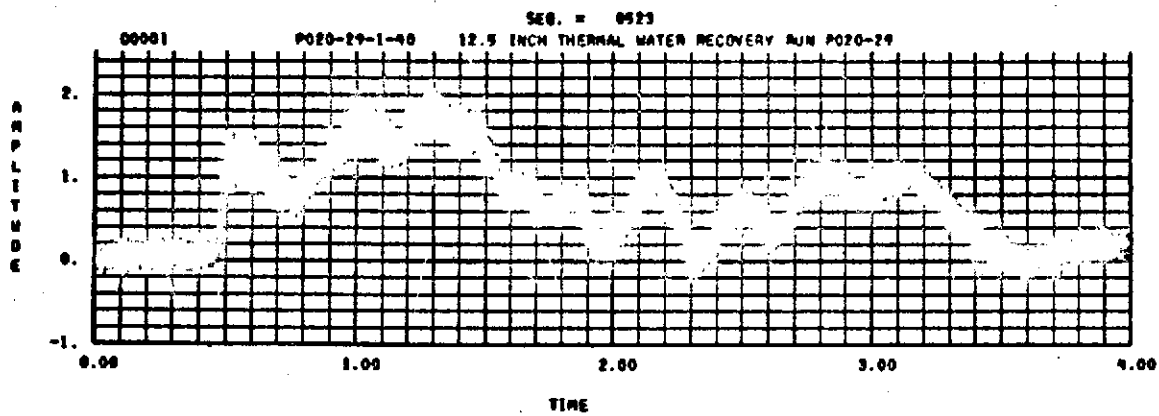
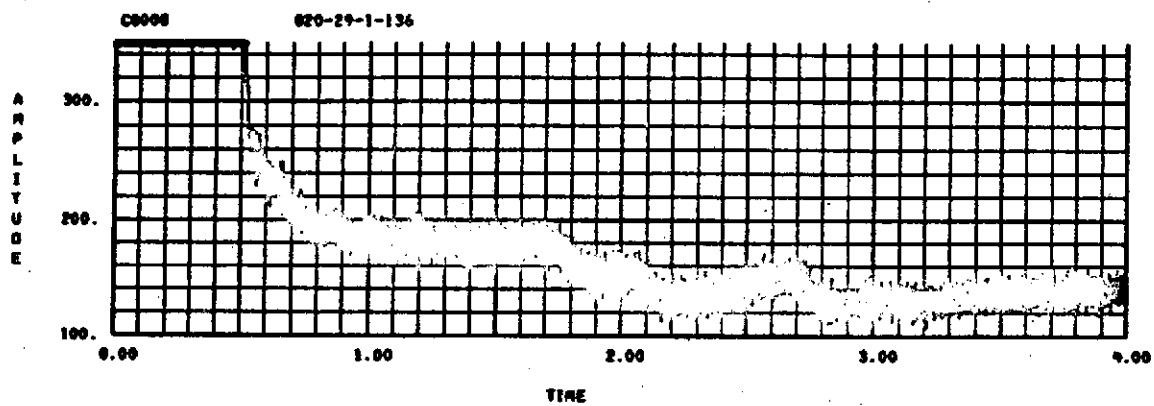
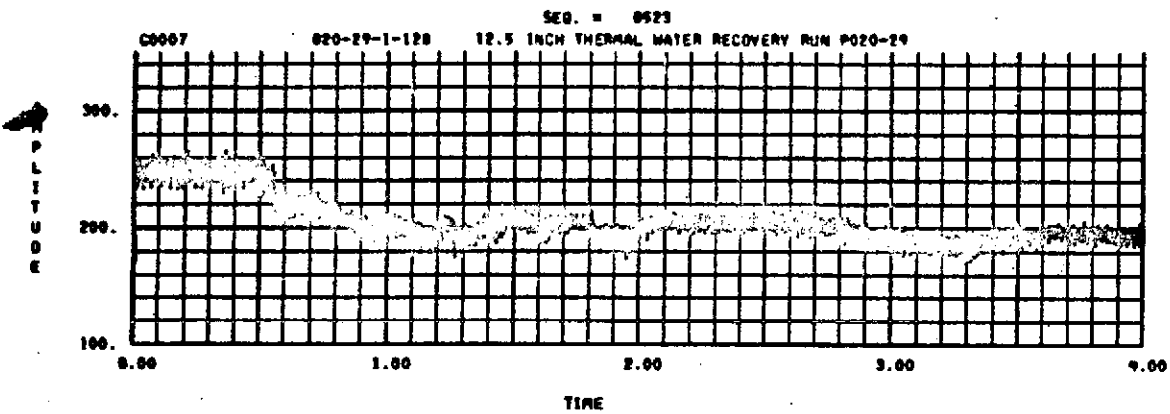


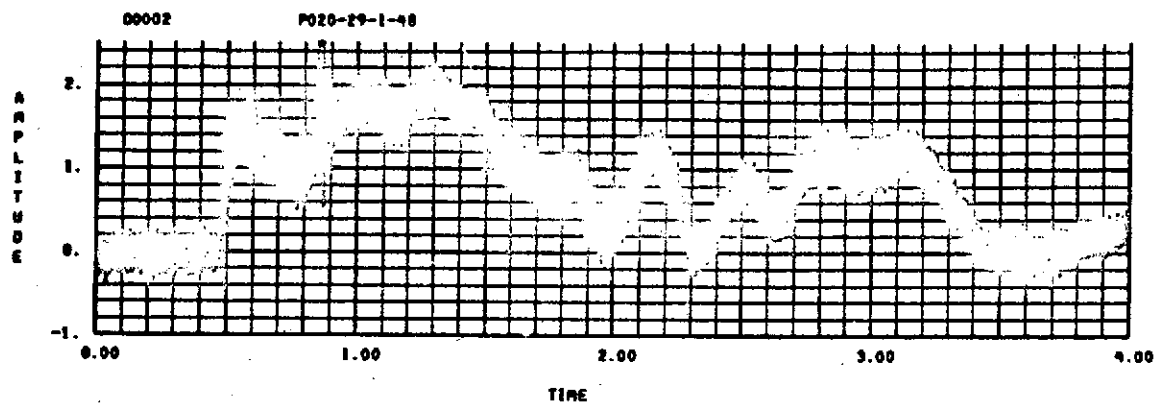
SEG. # 0523

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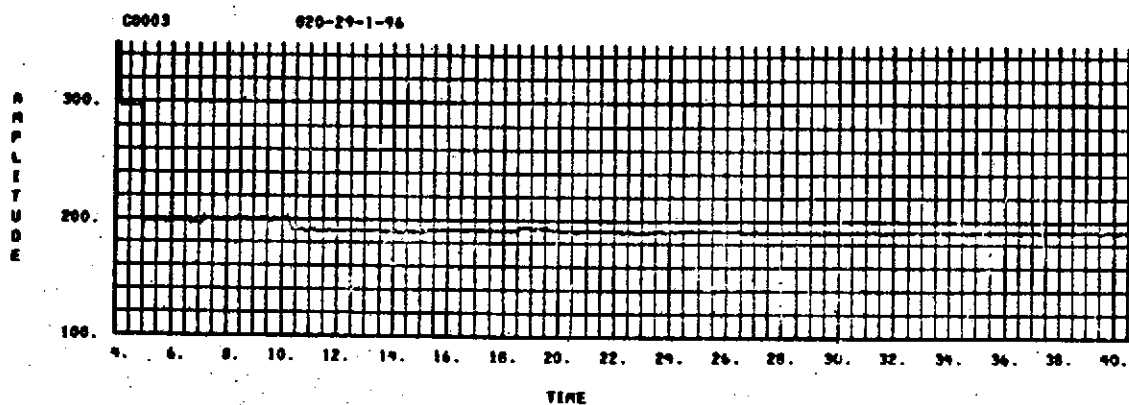
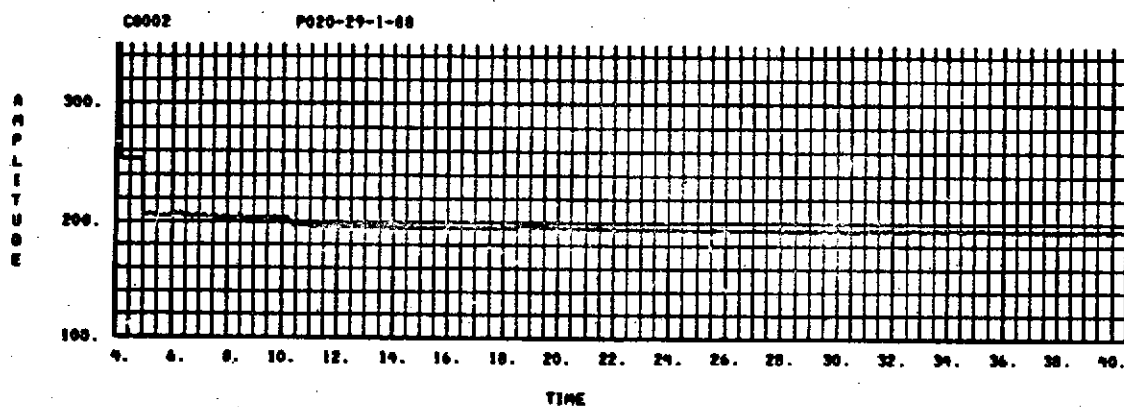
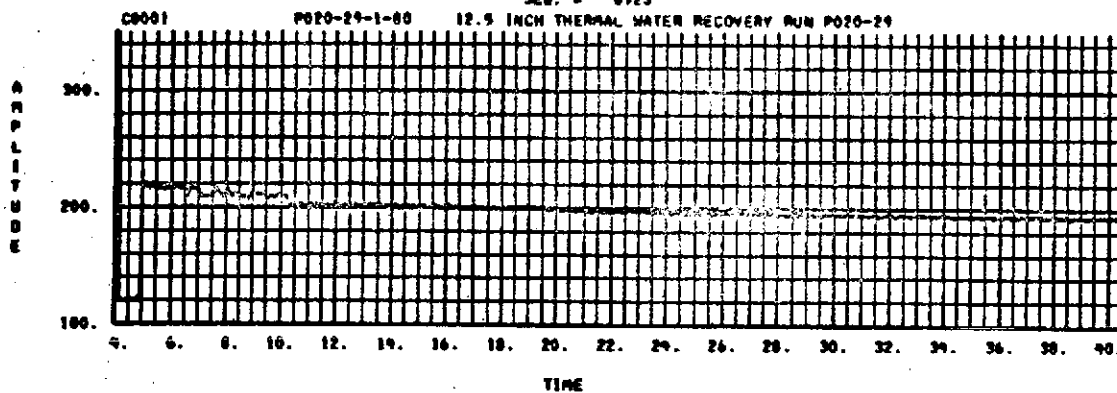


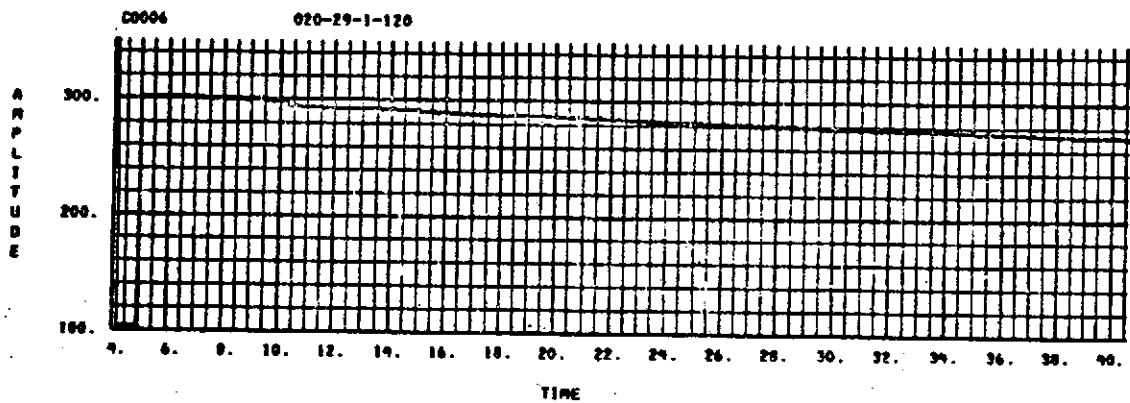
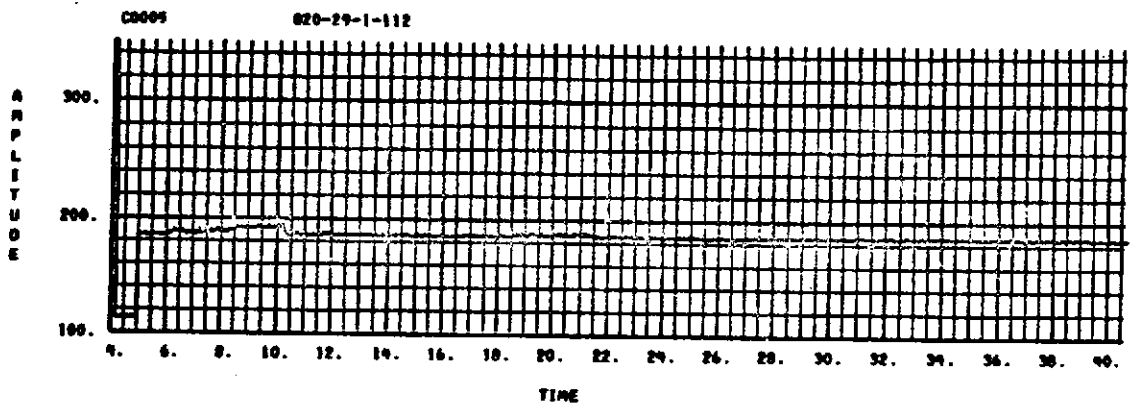
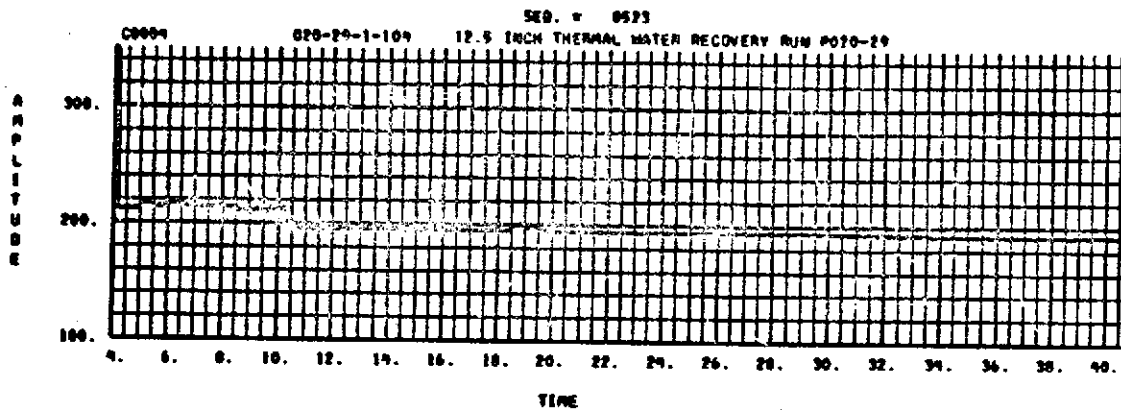


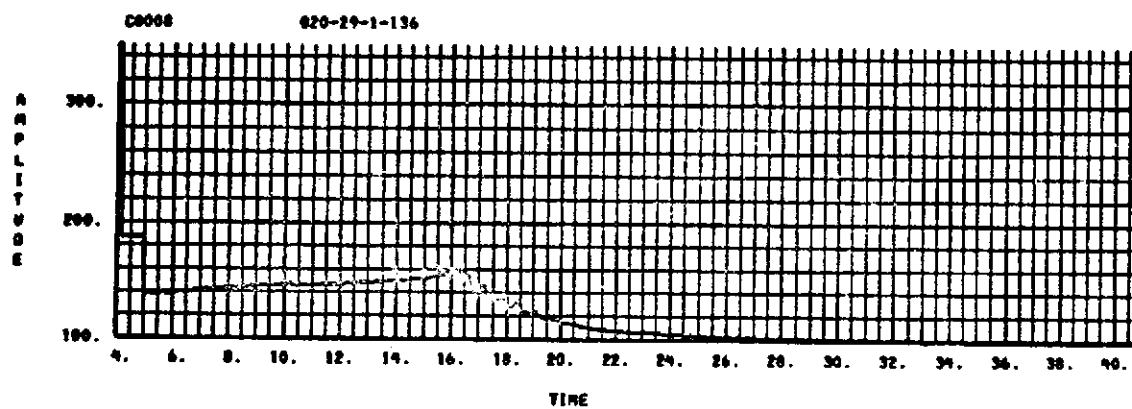
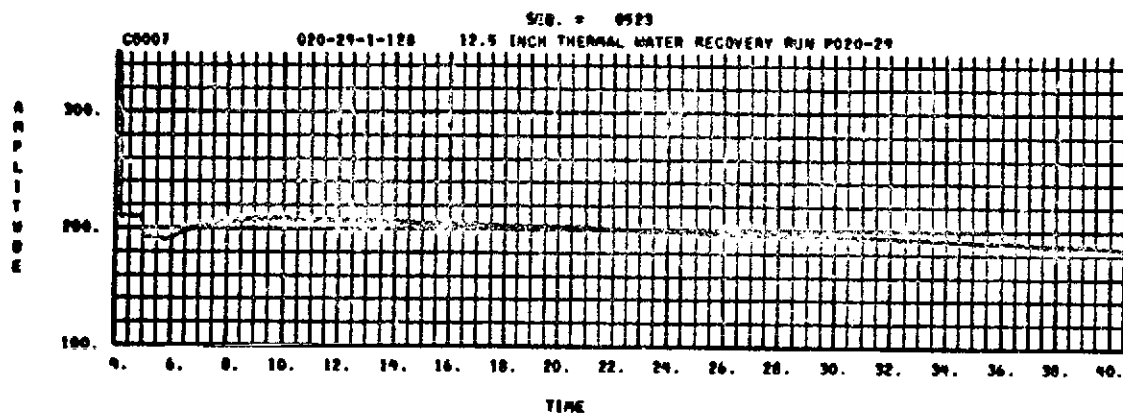


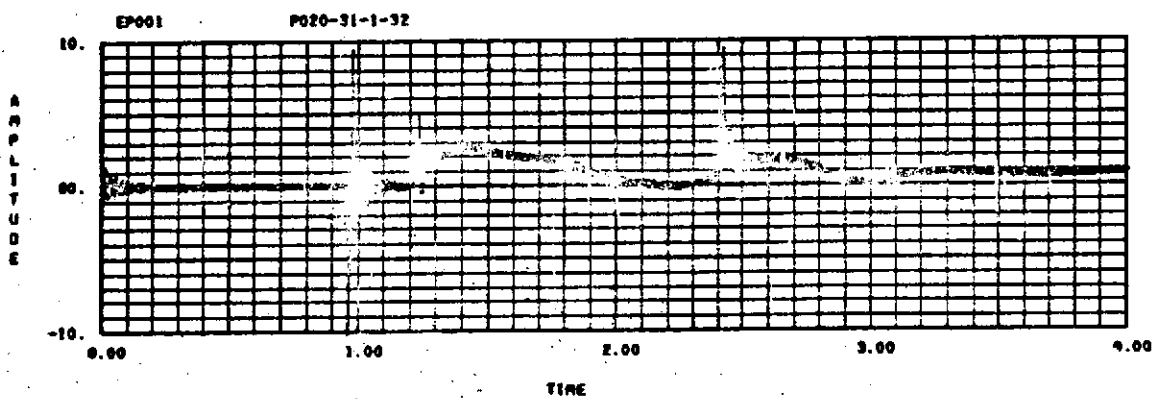
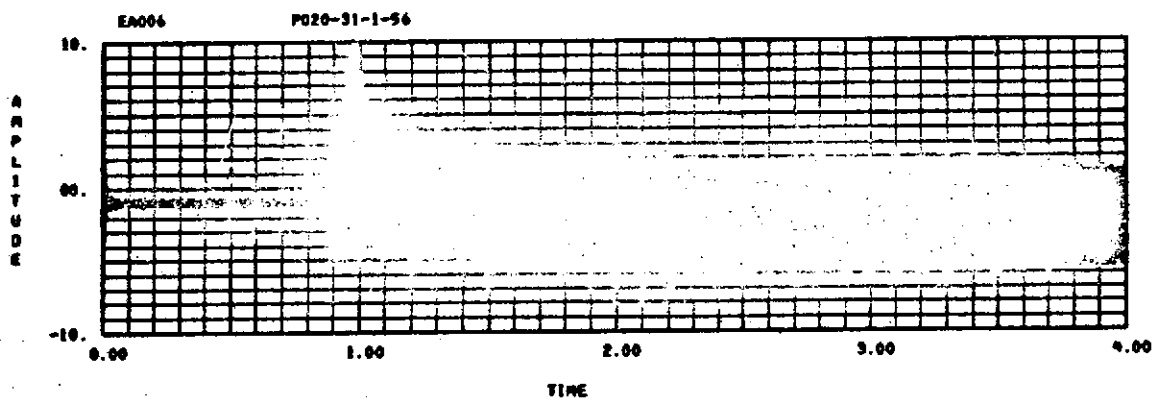
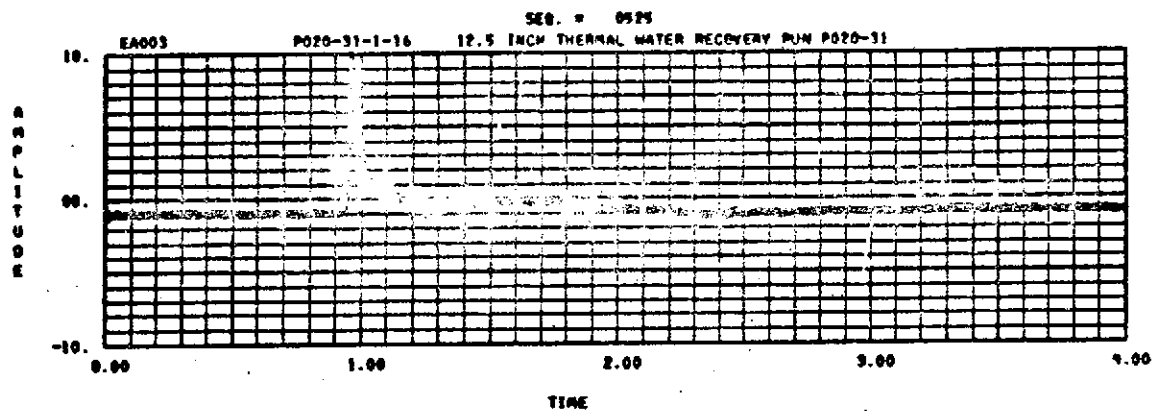
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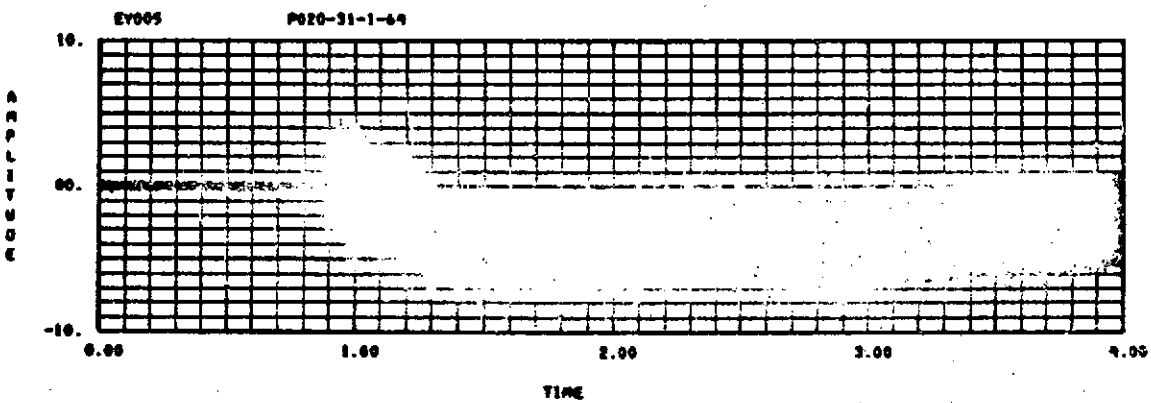
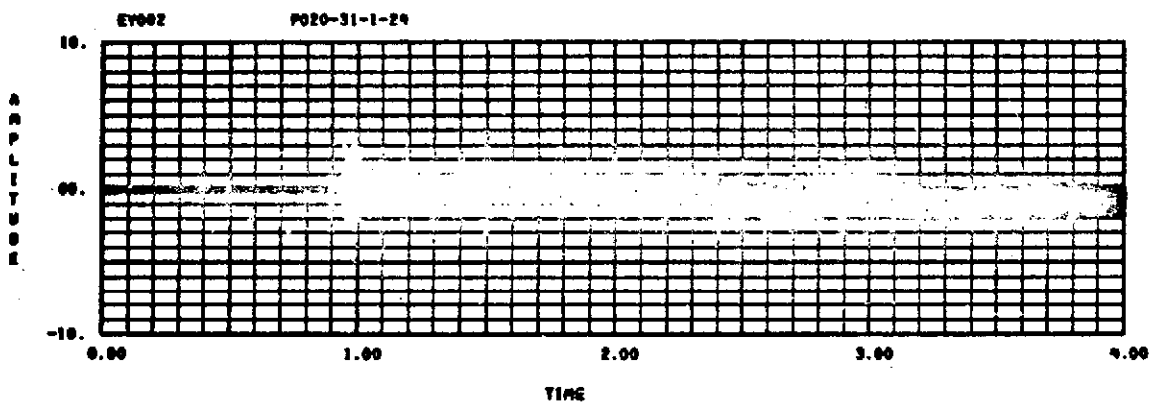
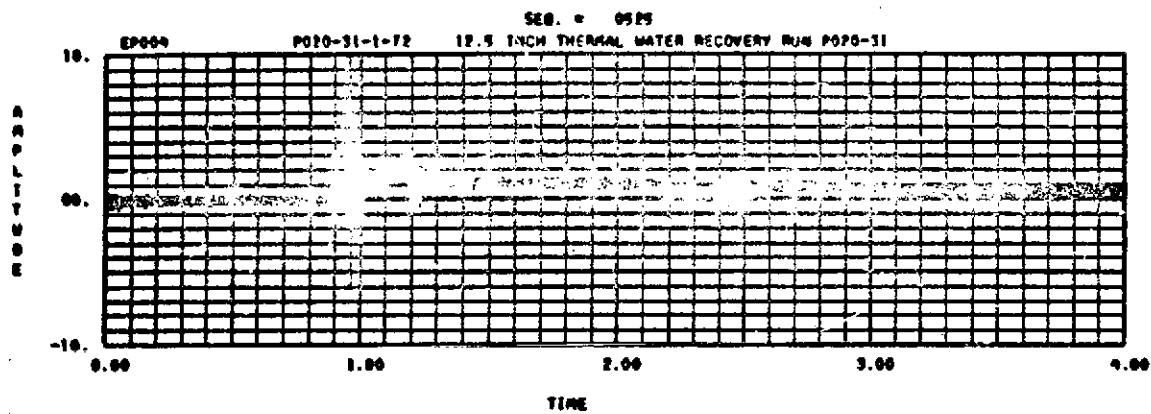
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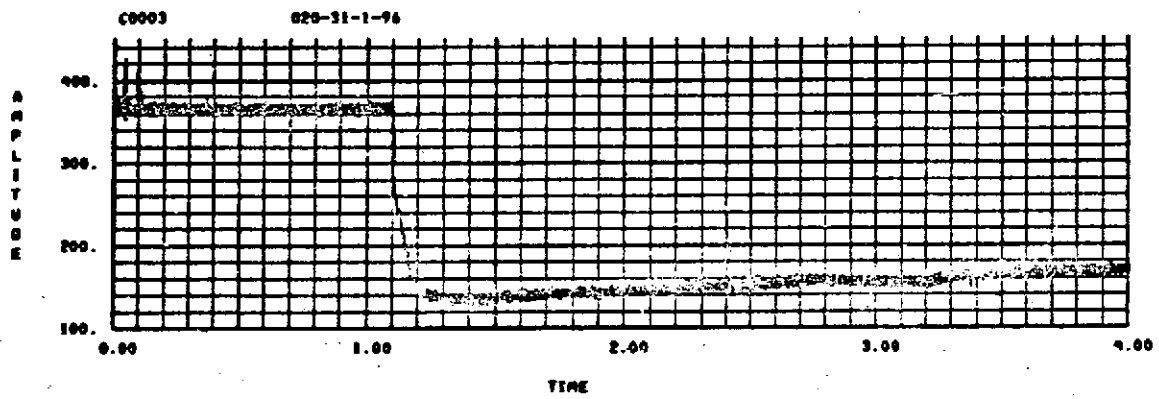
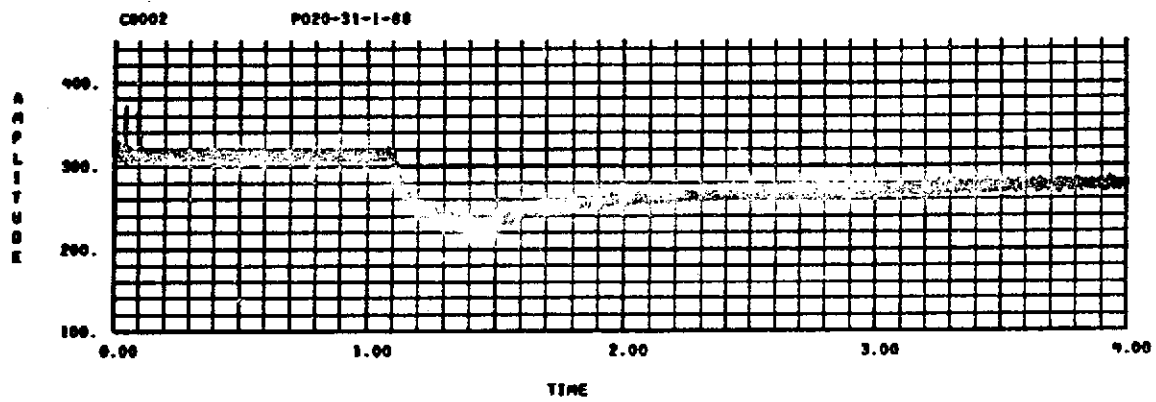
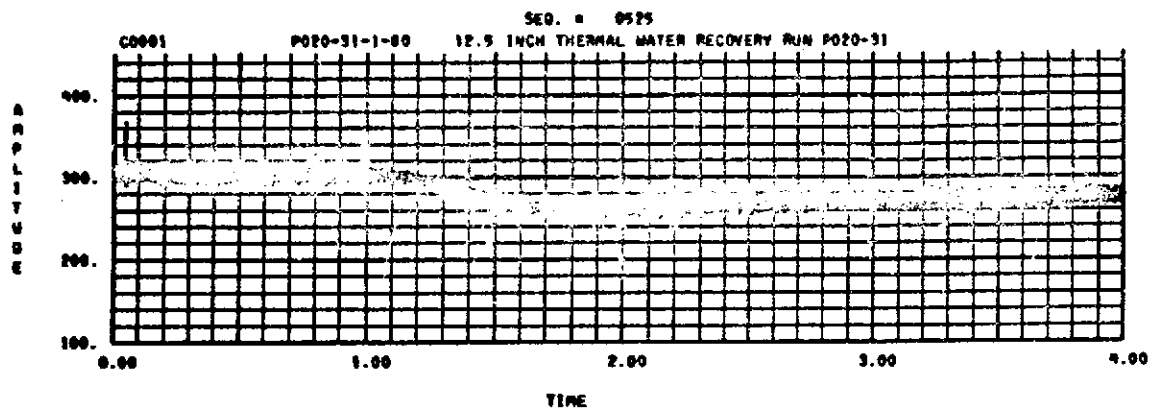






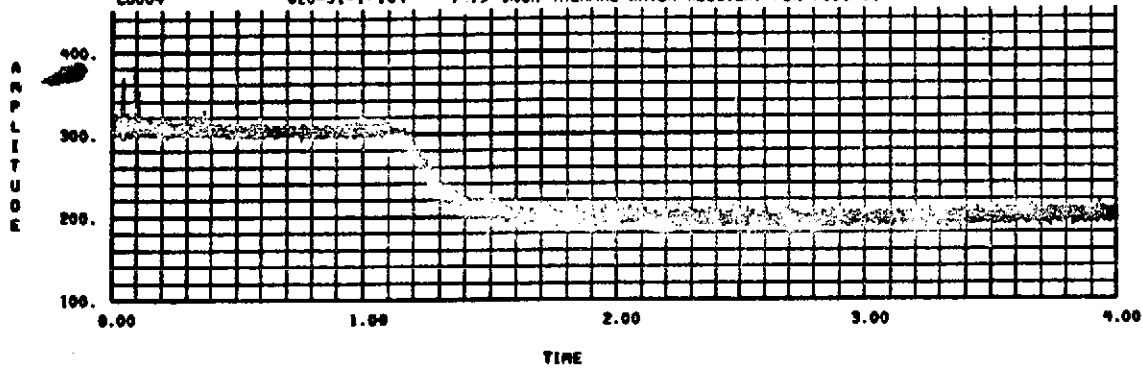




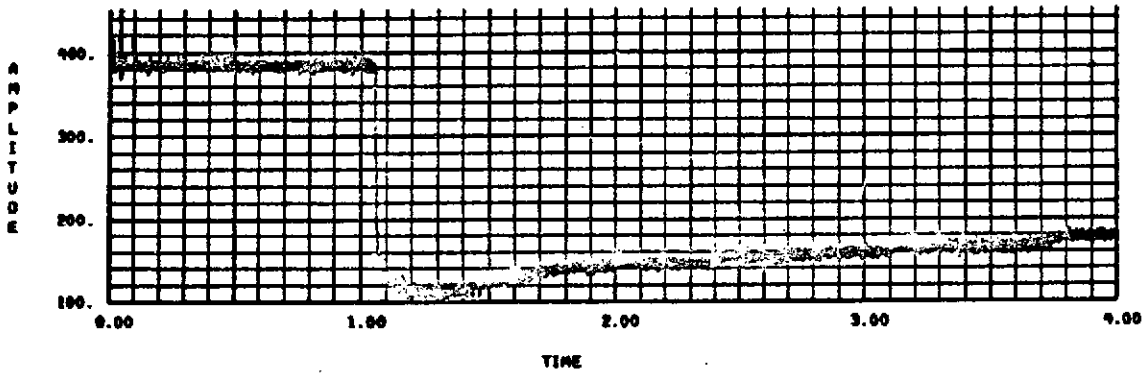


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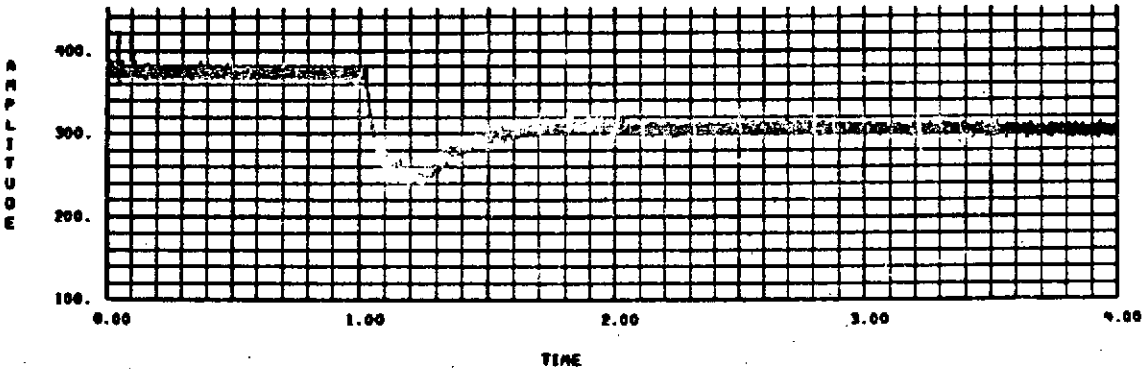
C0004 020-31-1-104 19.5 INCH THERMAL WATER RECOVERY RUN P020-31

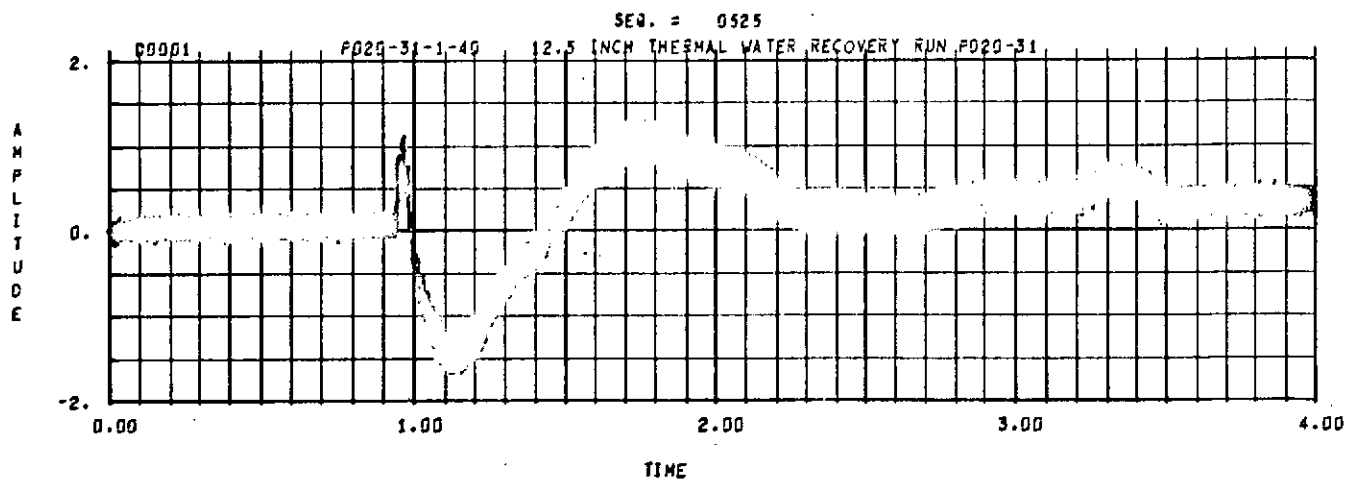
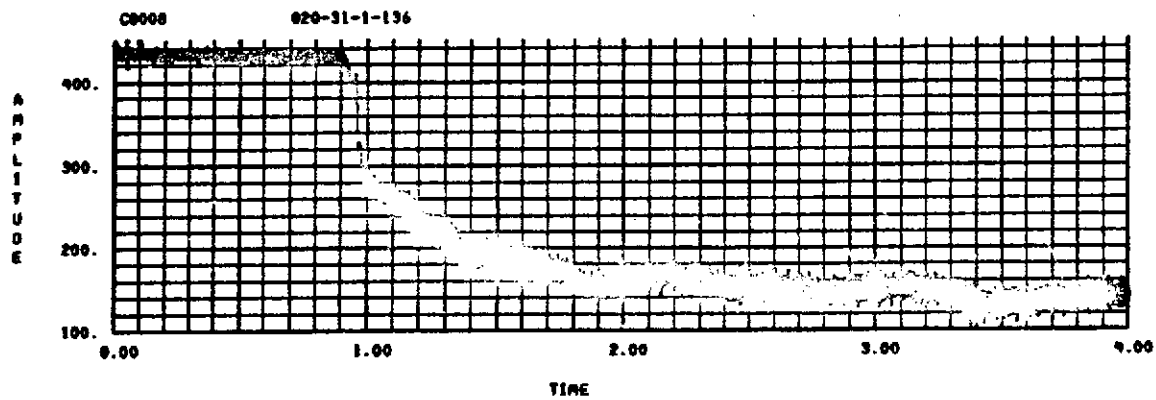
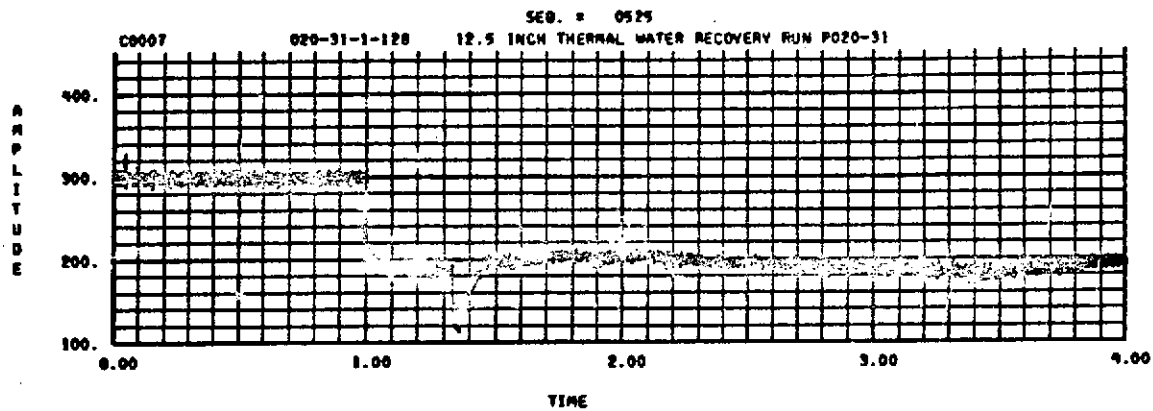


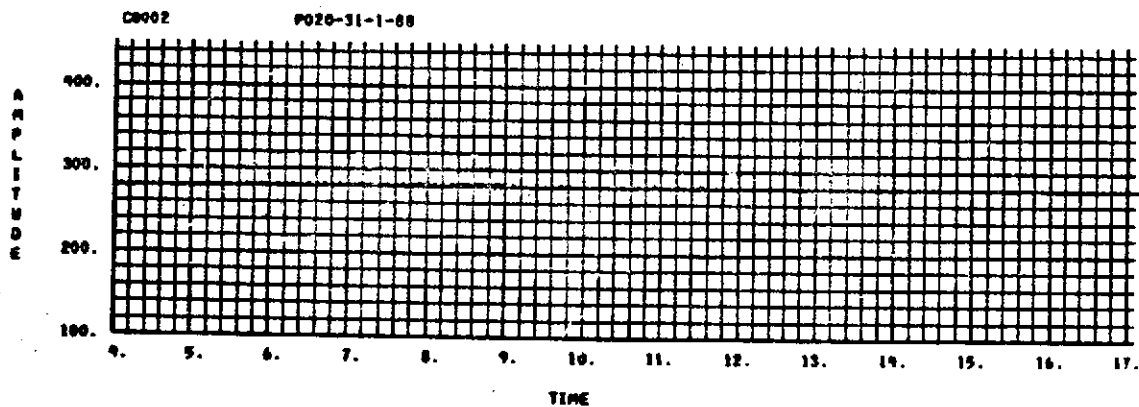
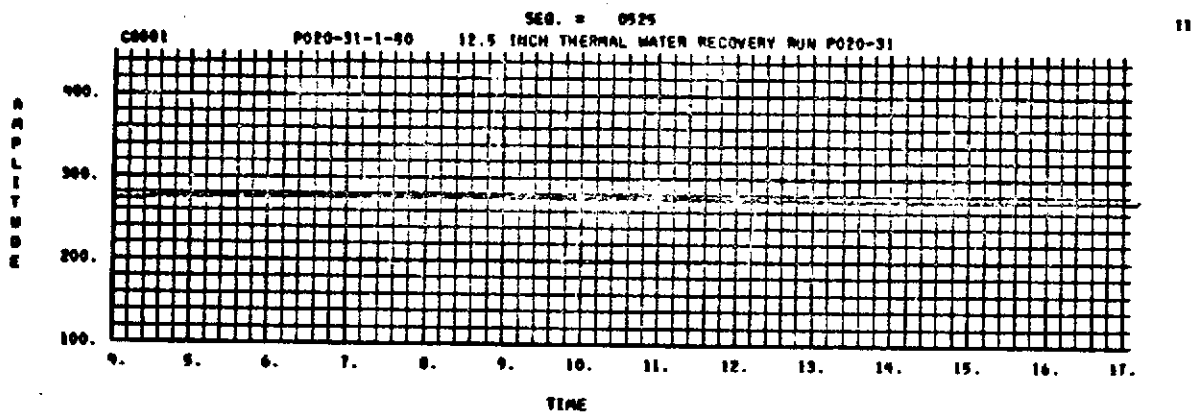
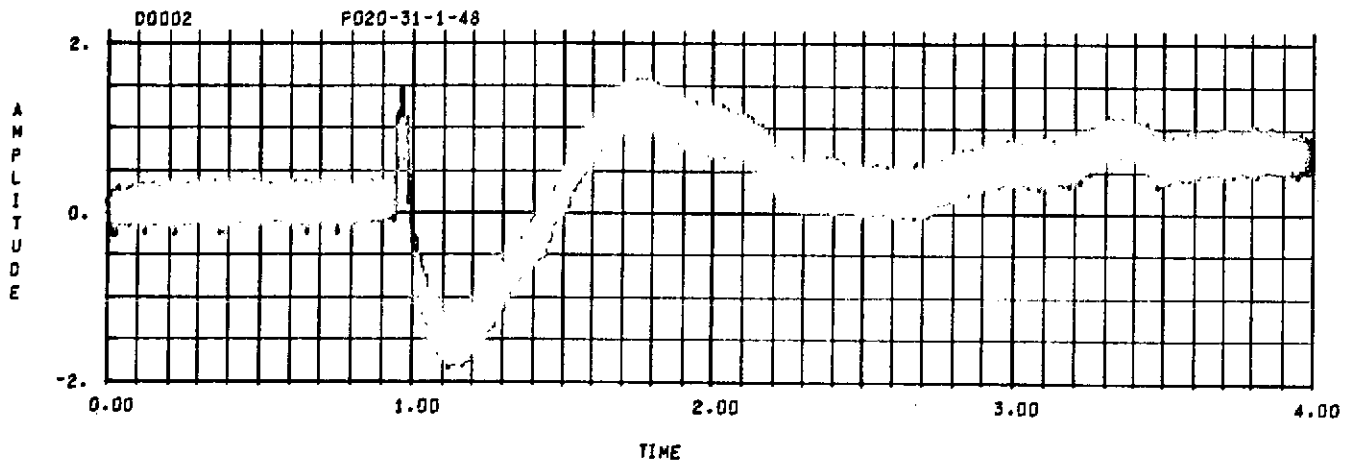
C0005 020-31-1-112

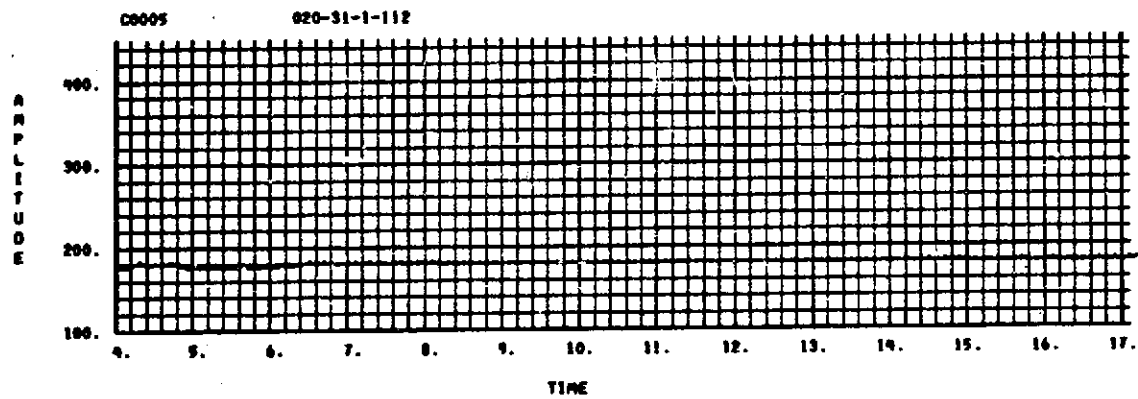
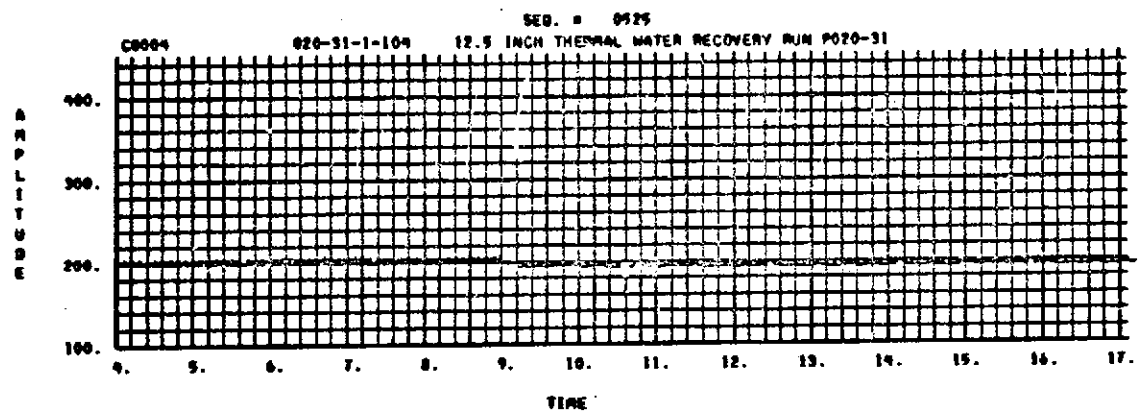
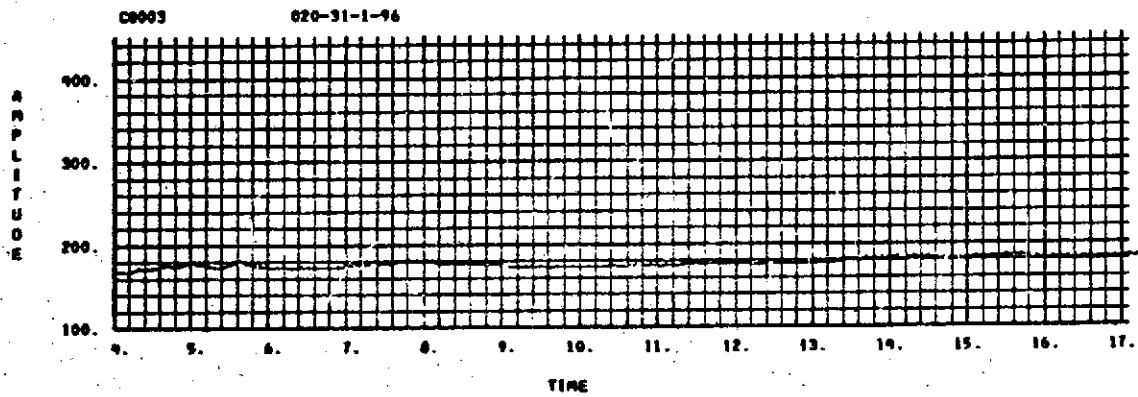


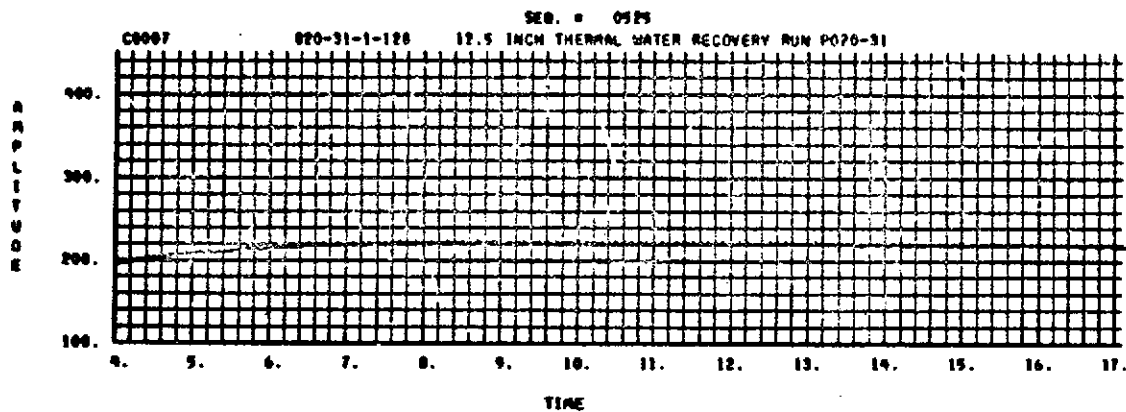
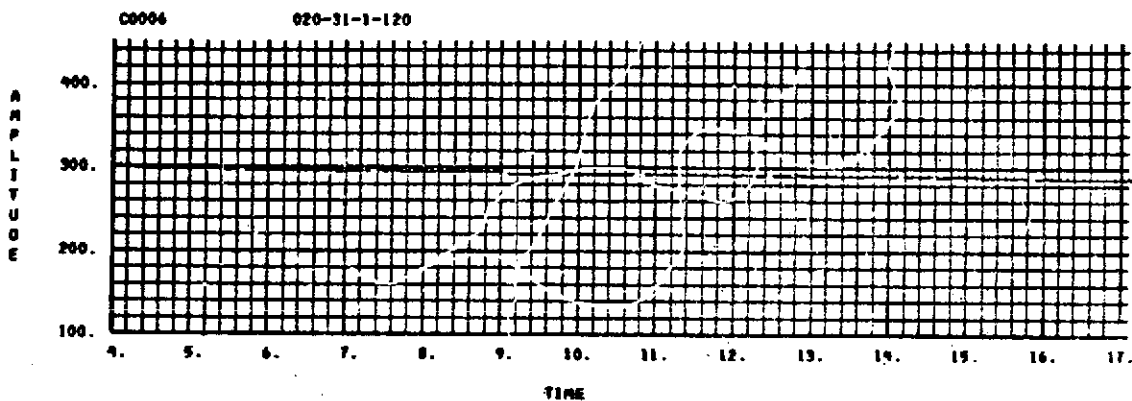
C0006 020-31-1-120



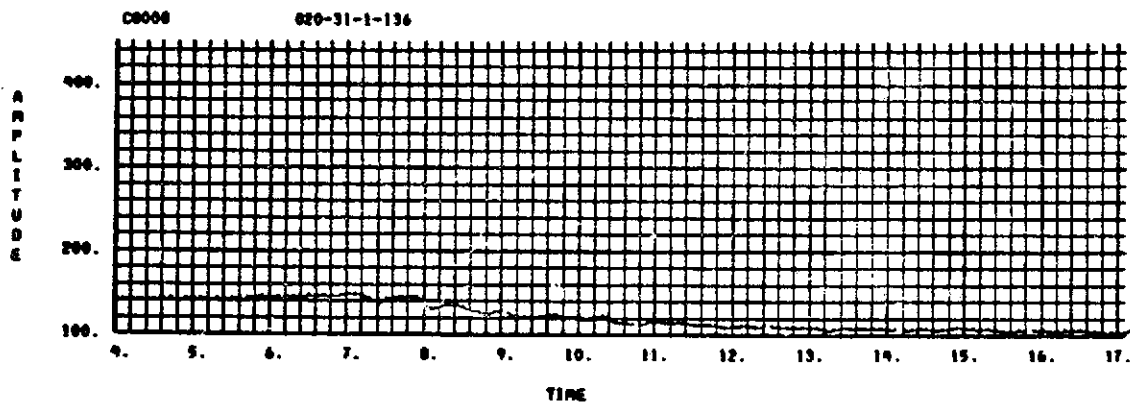


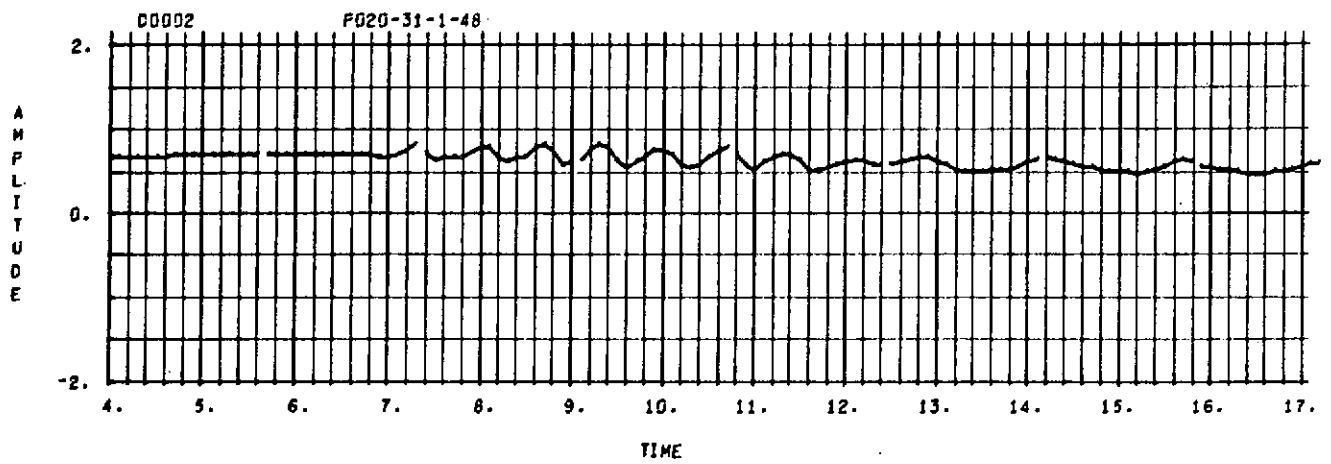
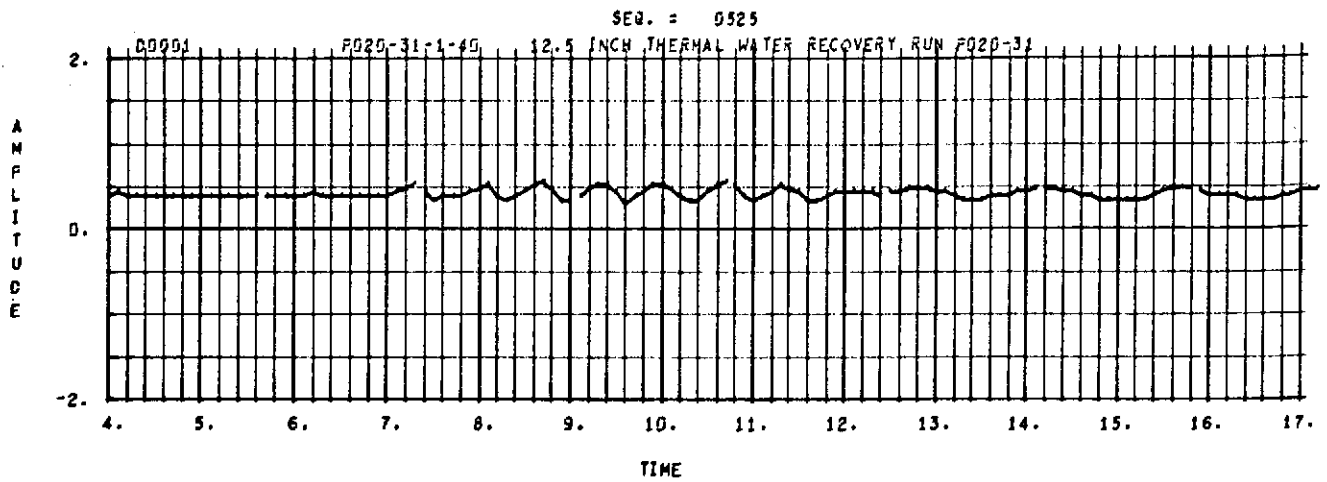


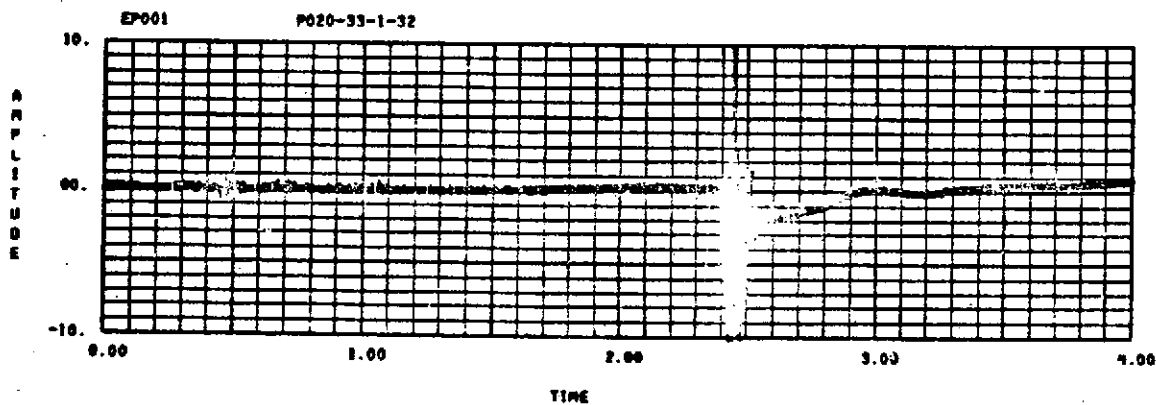
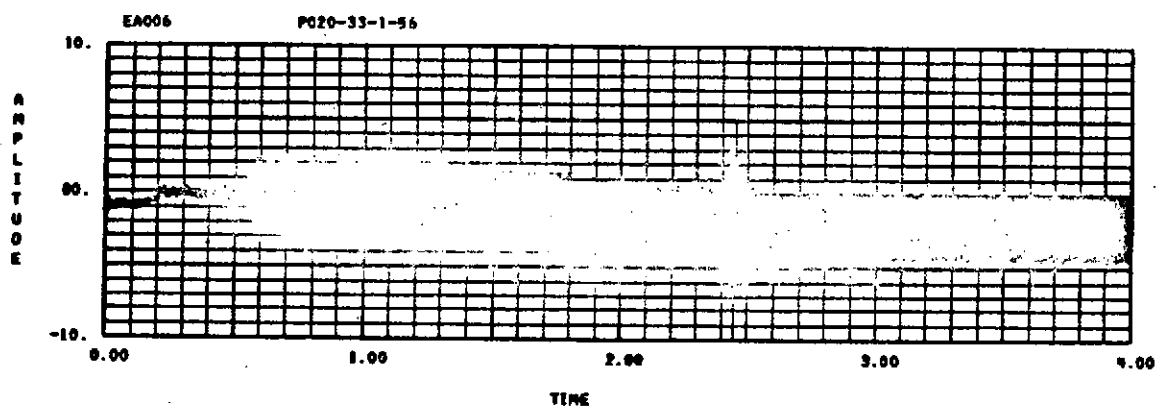
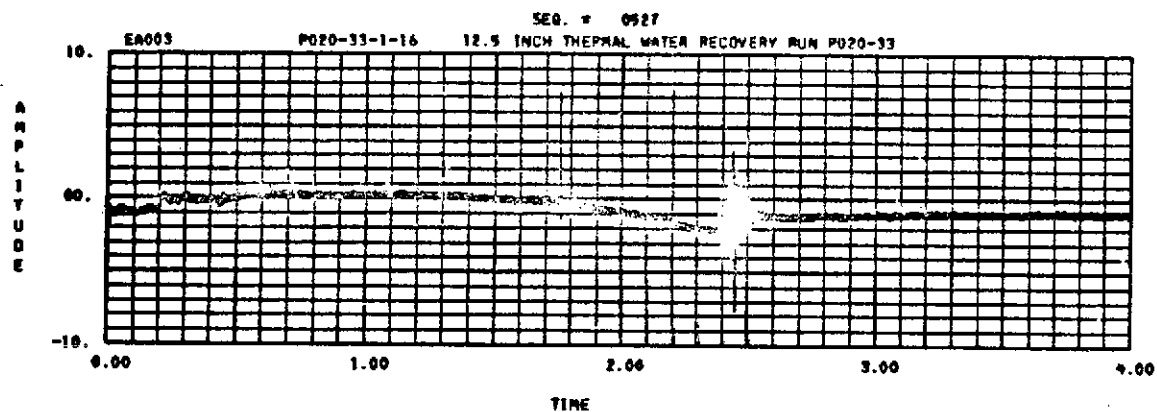


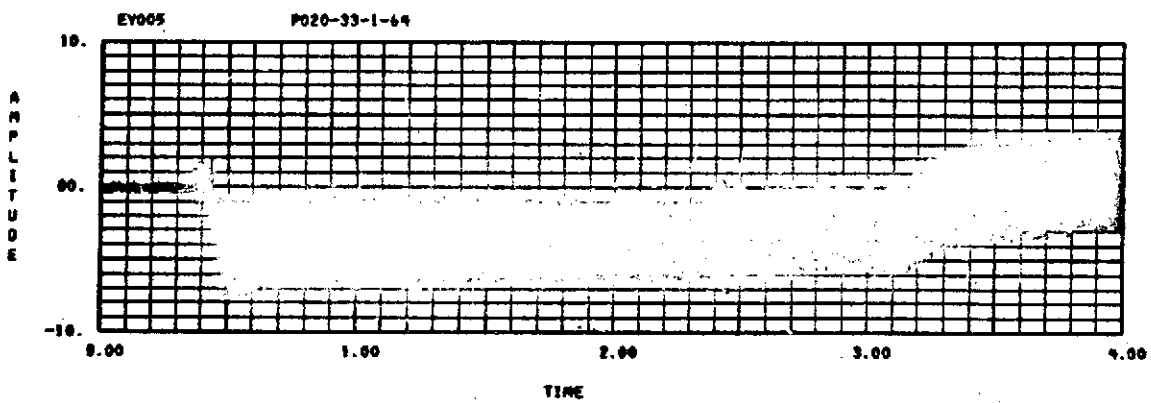
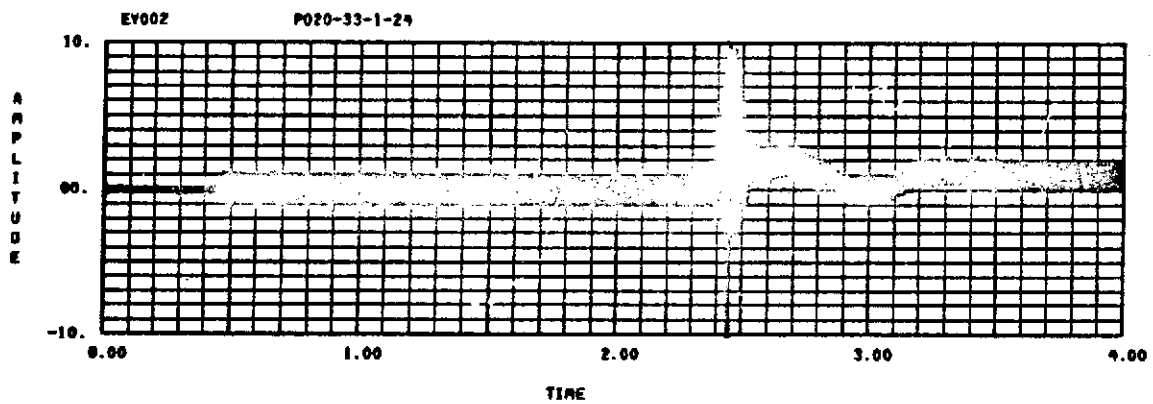
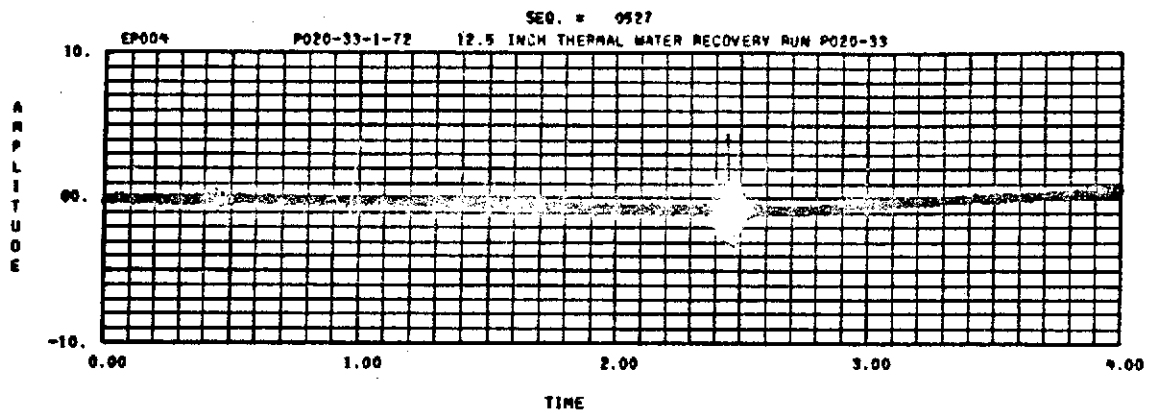


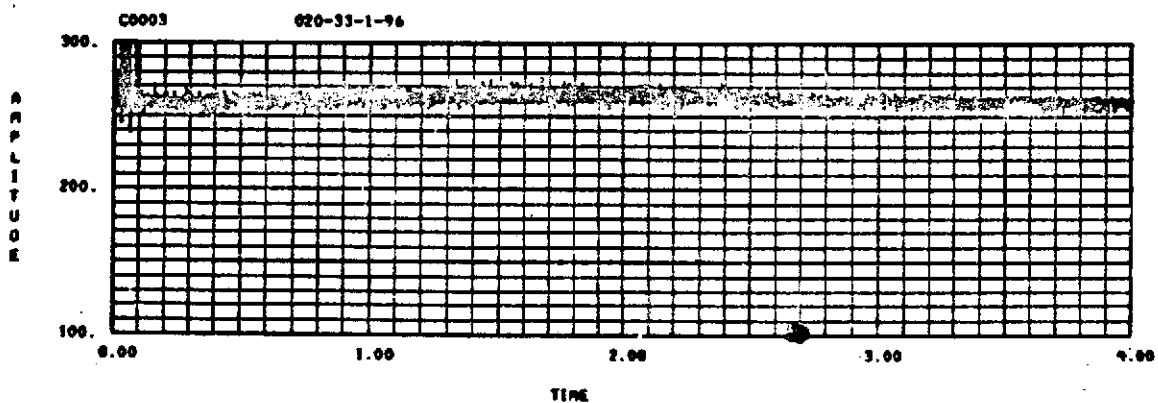
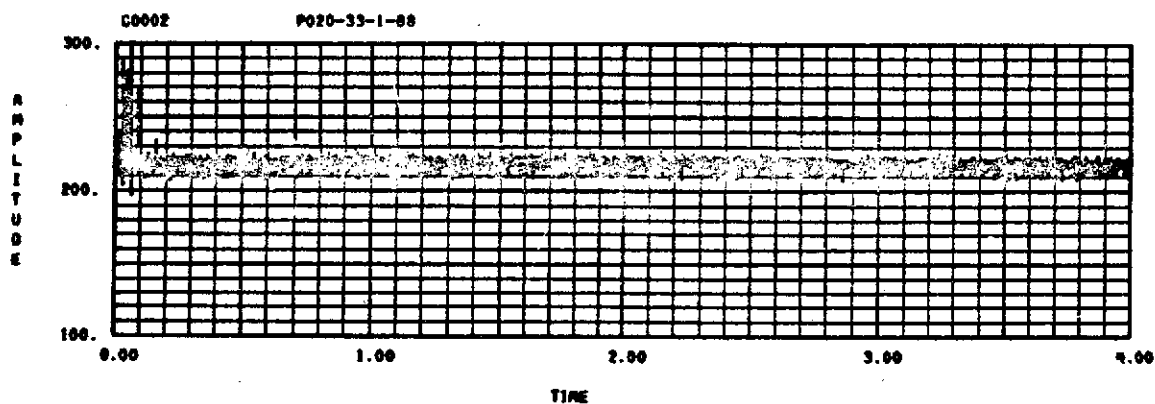
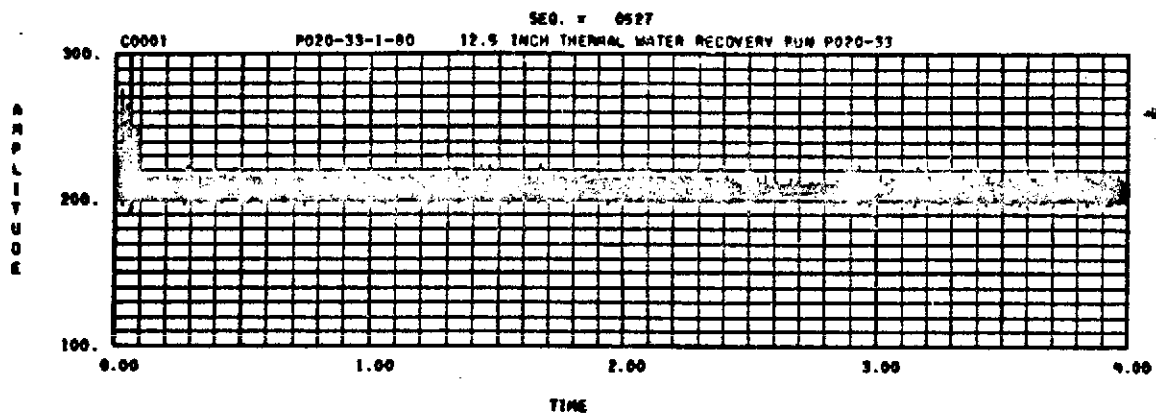
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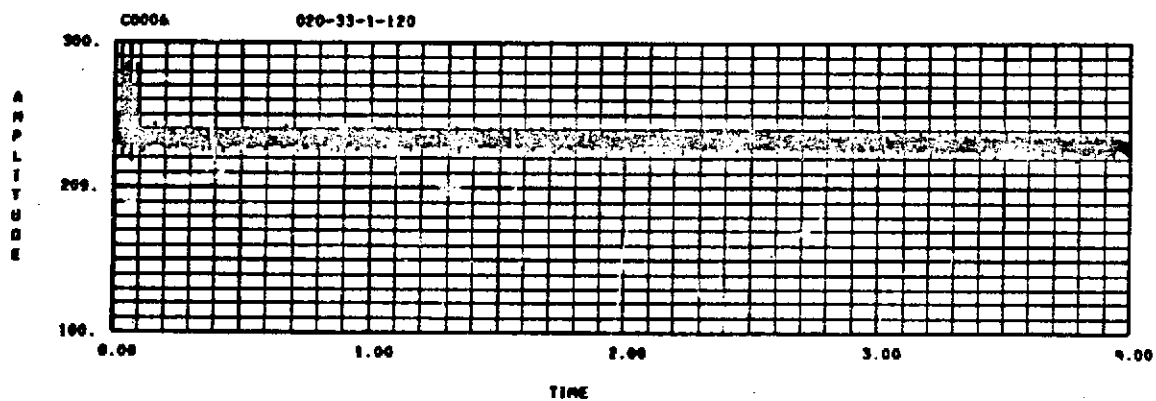
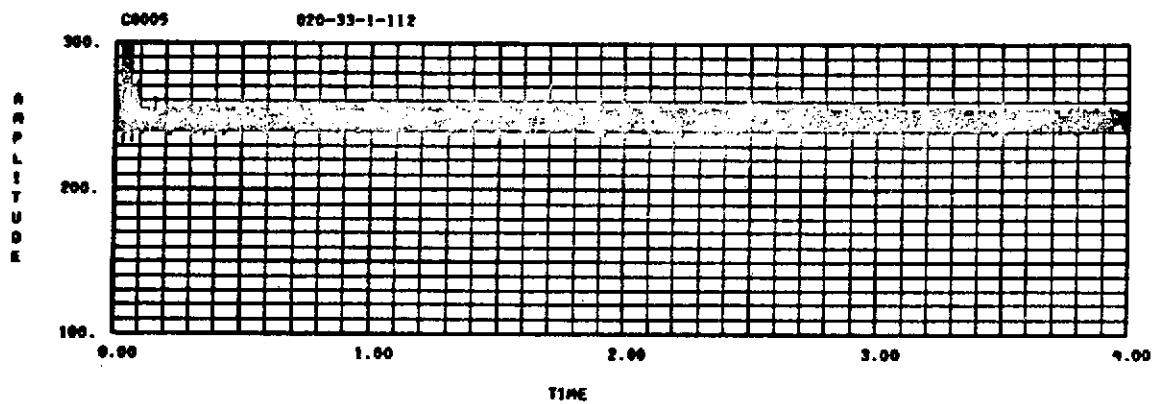
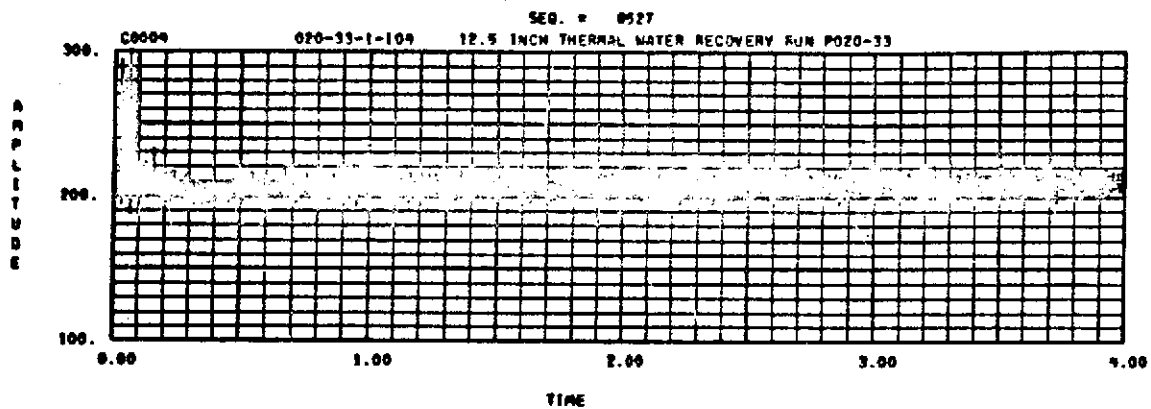


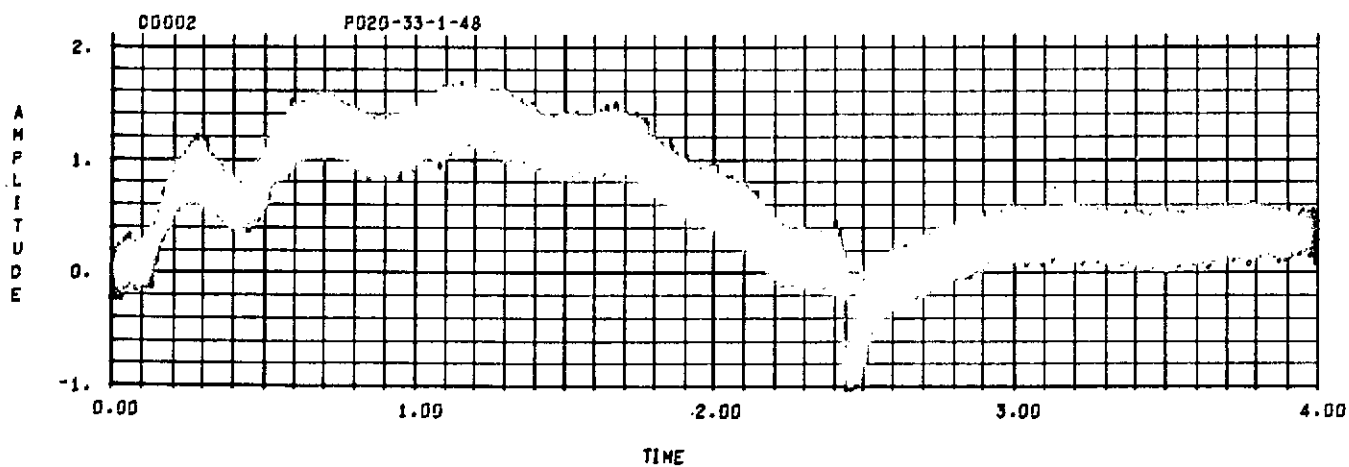
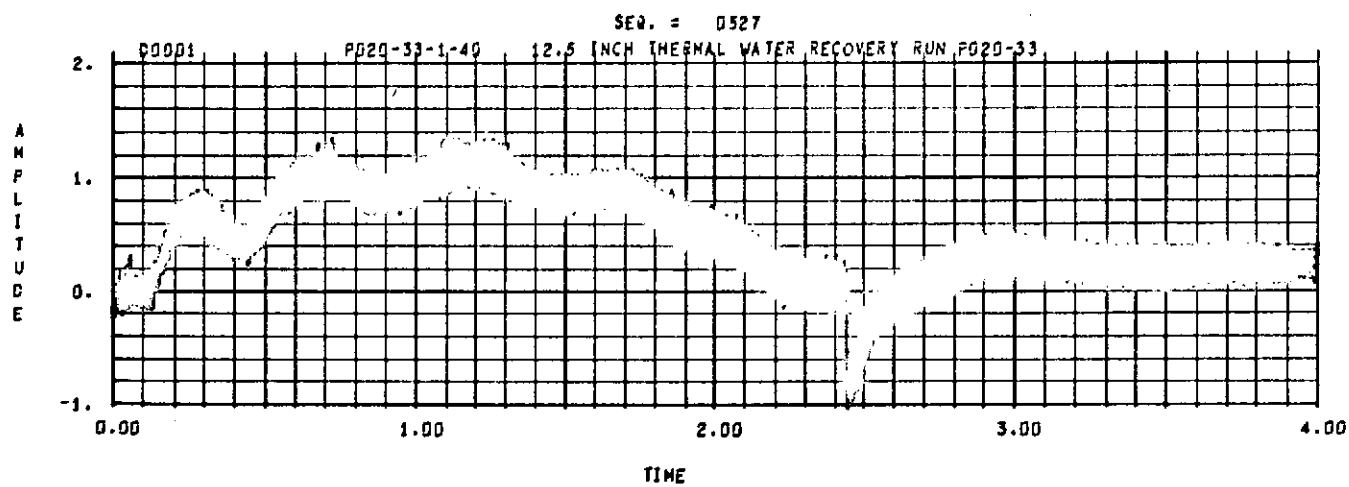
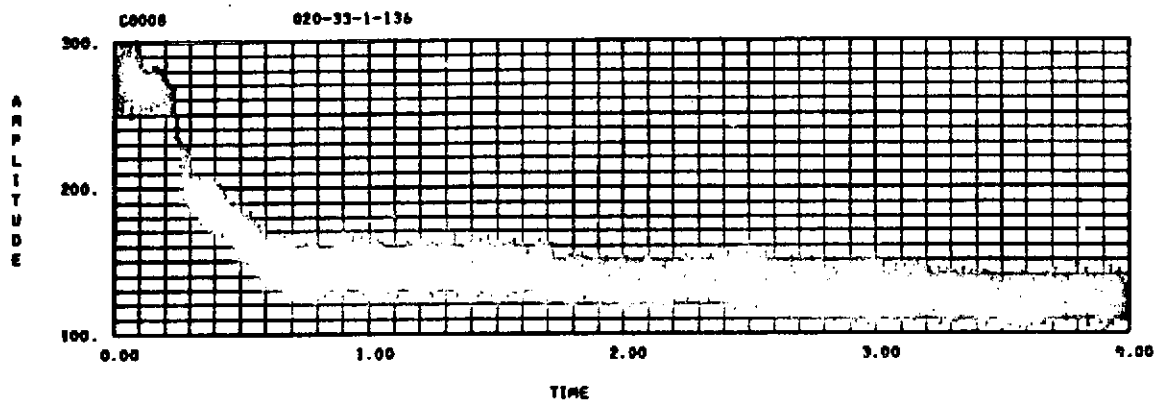


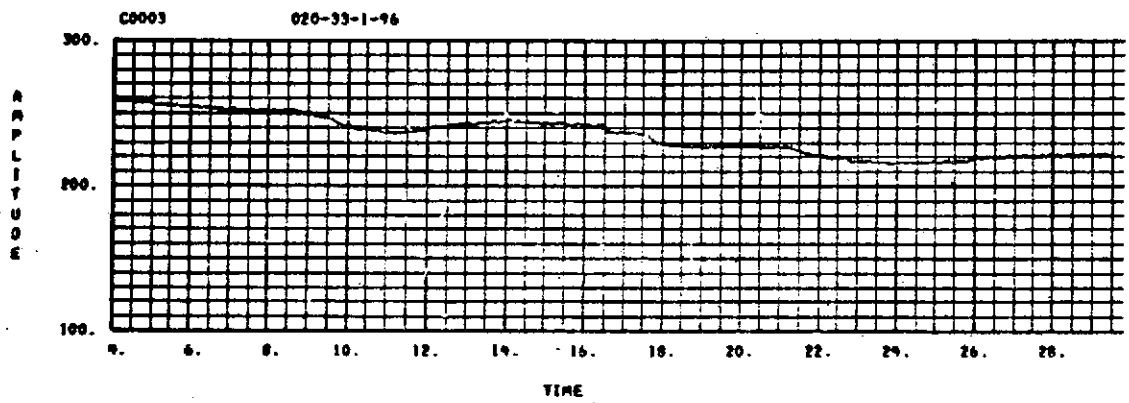
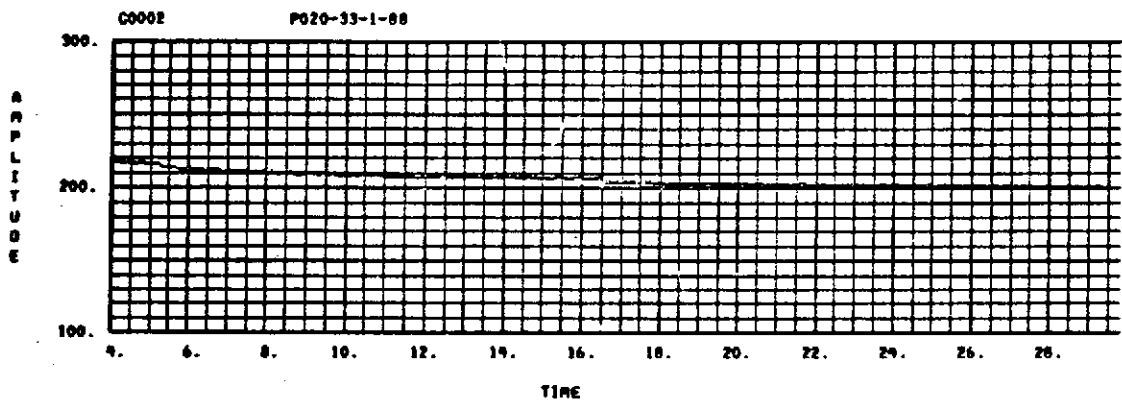
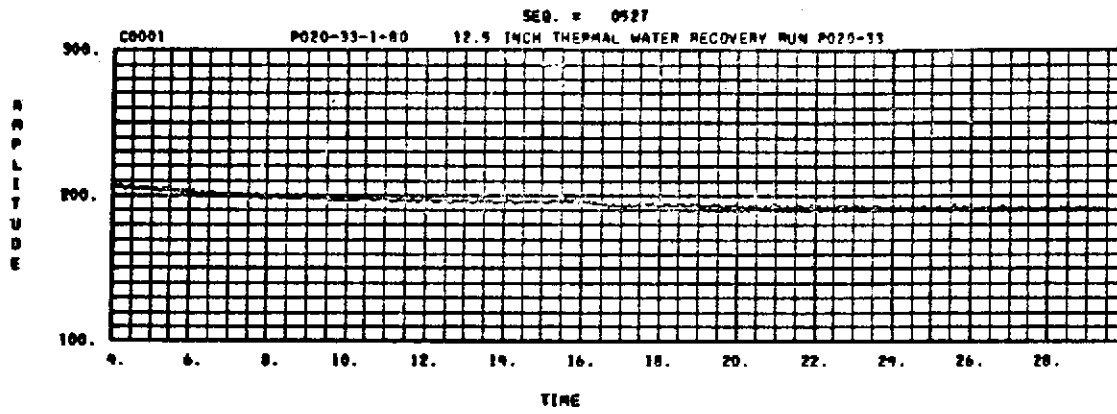






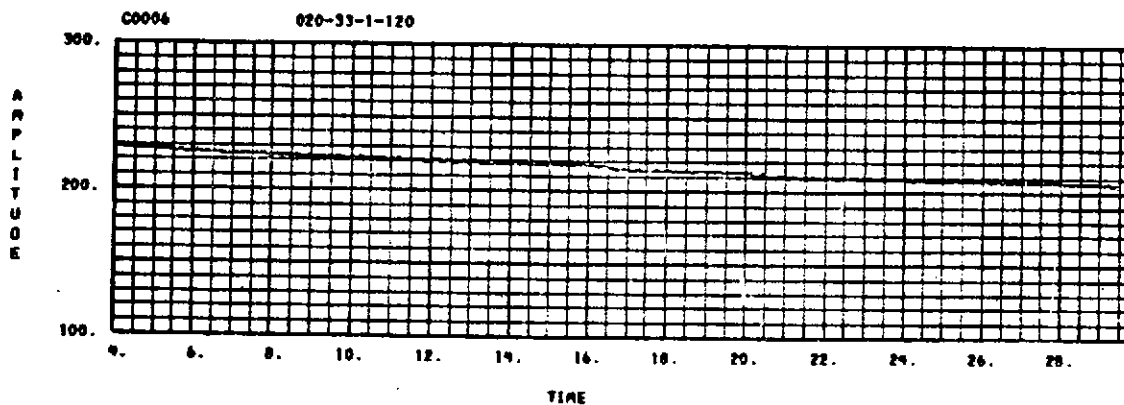
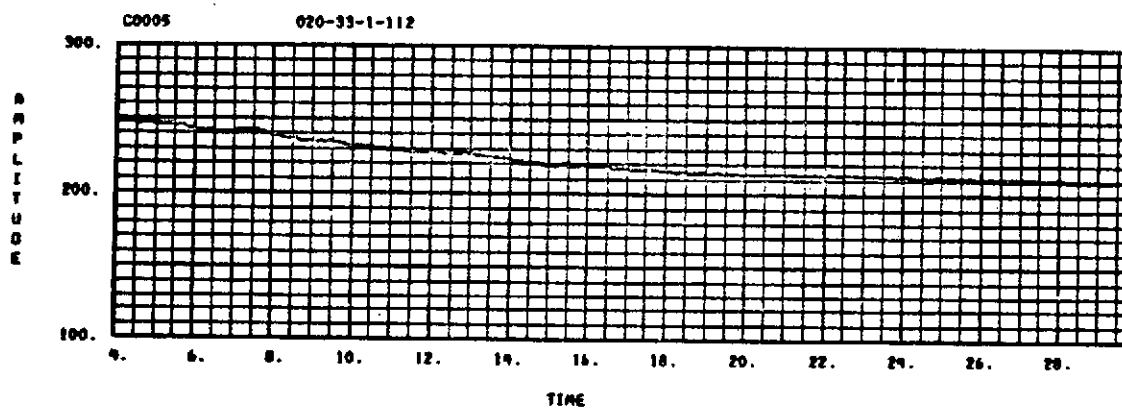
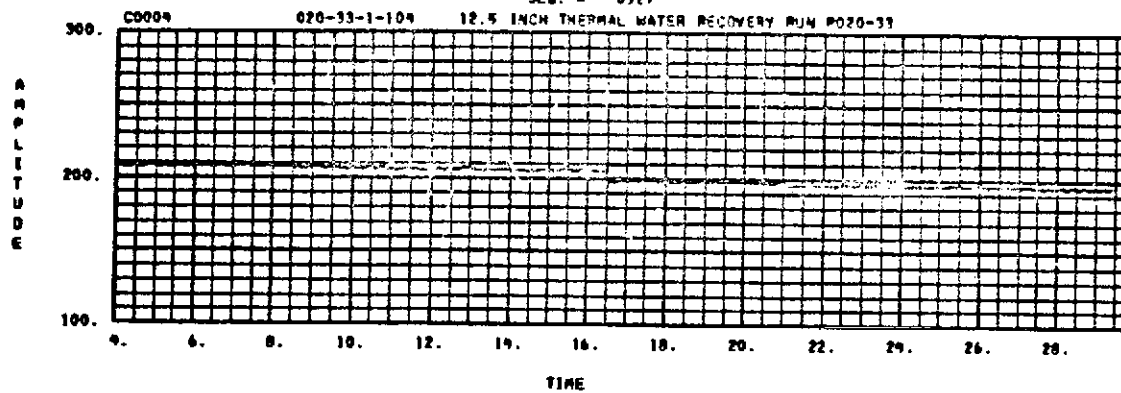


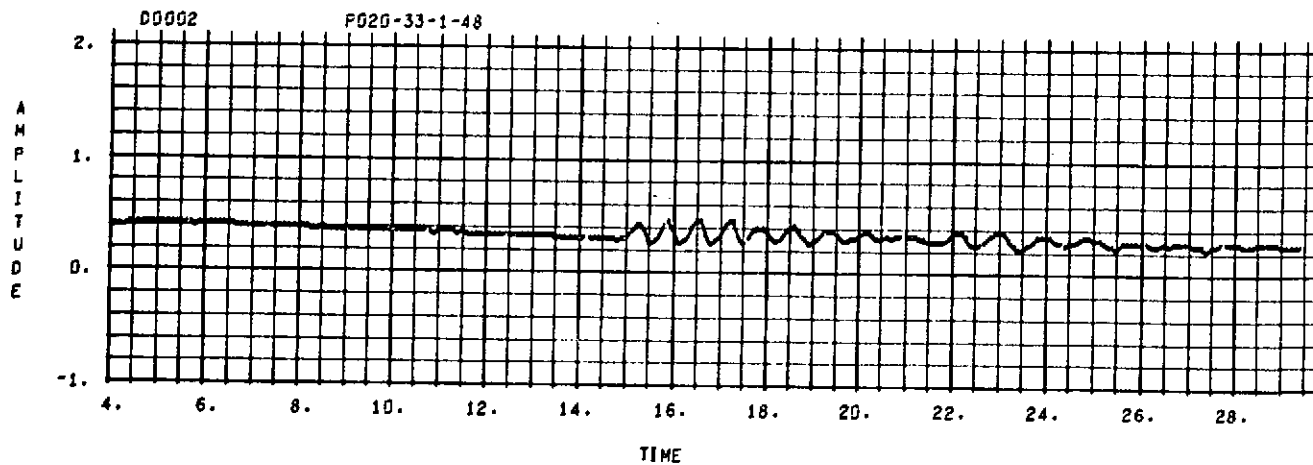
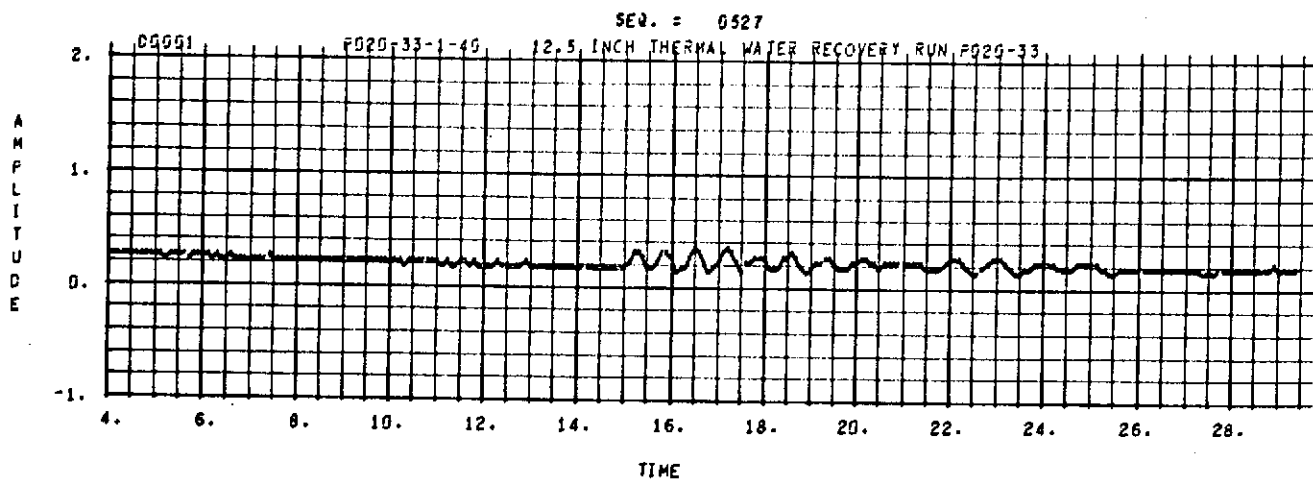
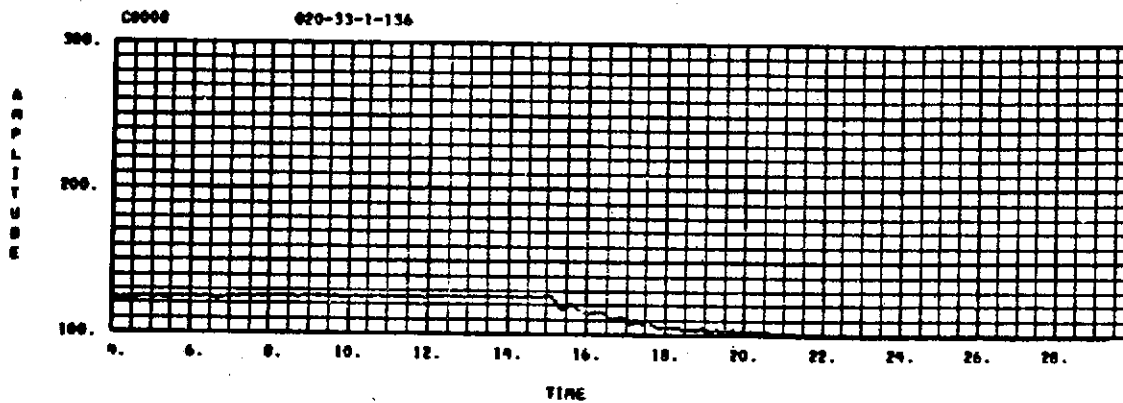




SEP. = 0527

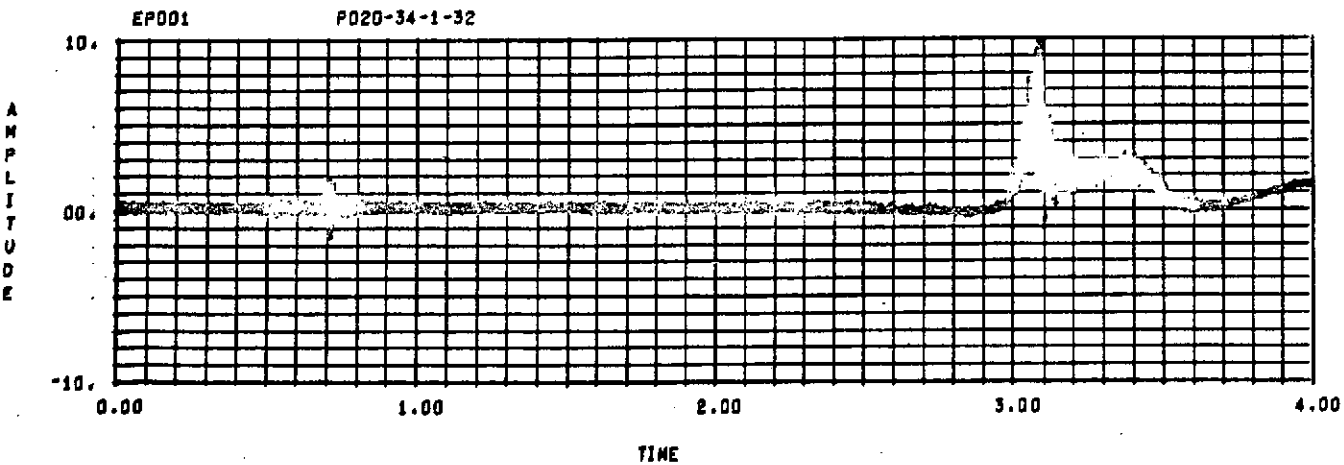
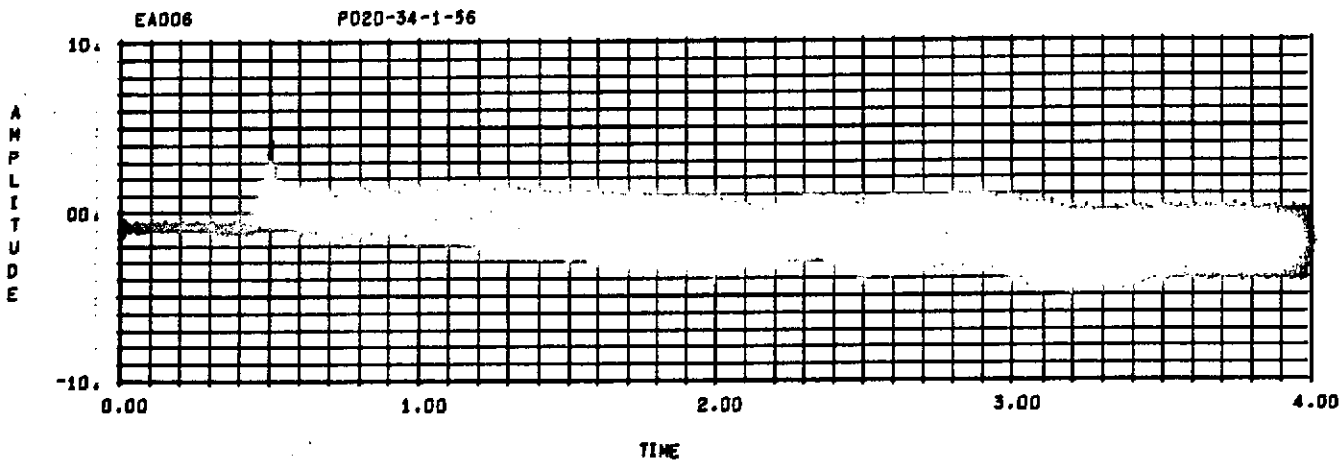
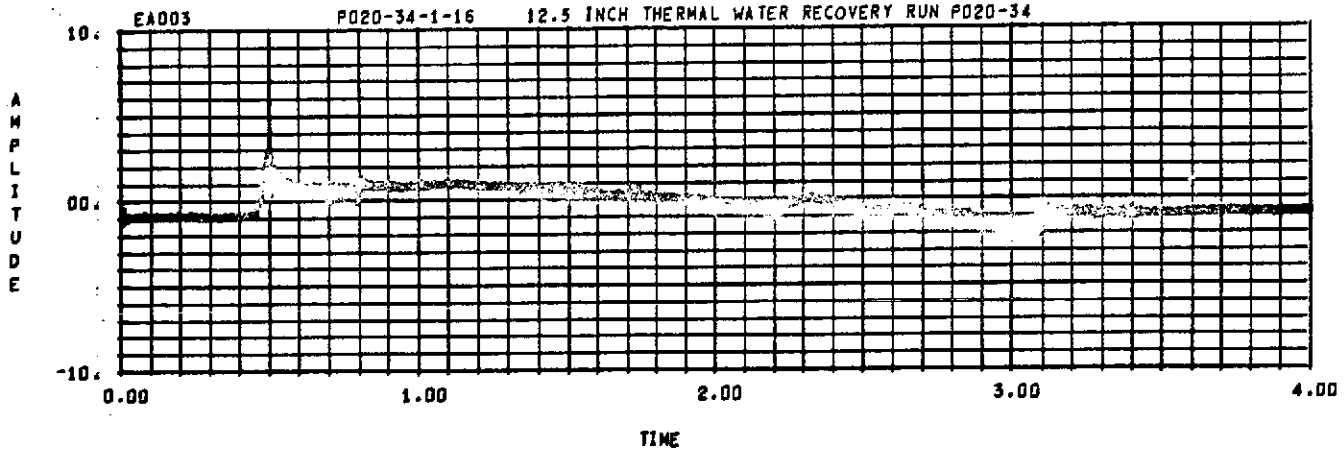
12

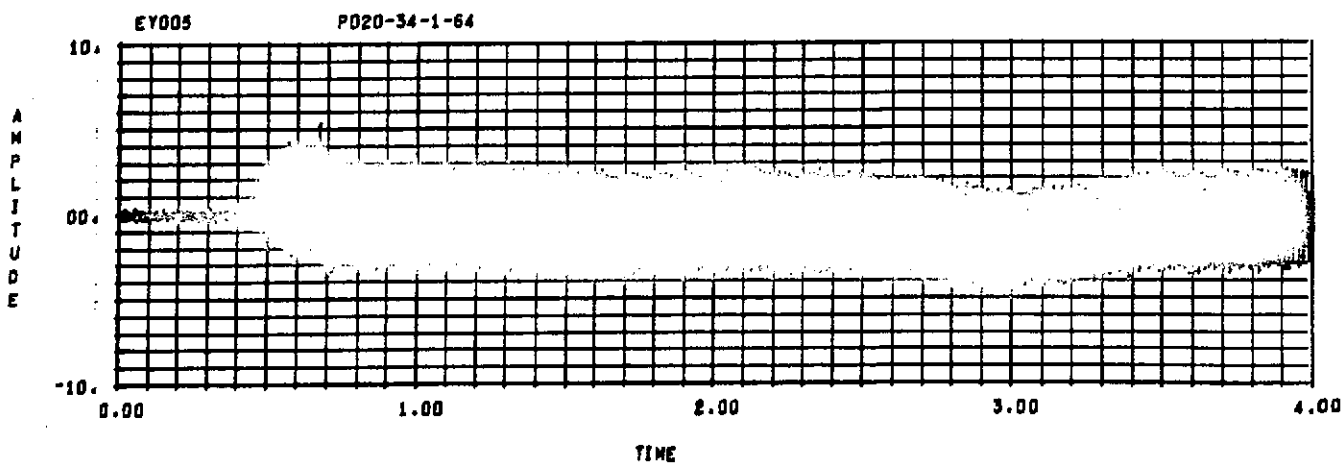
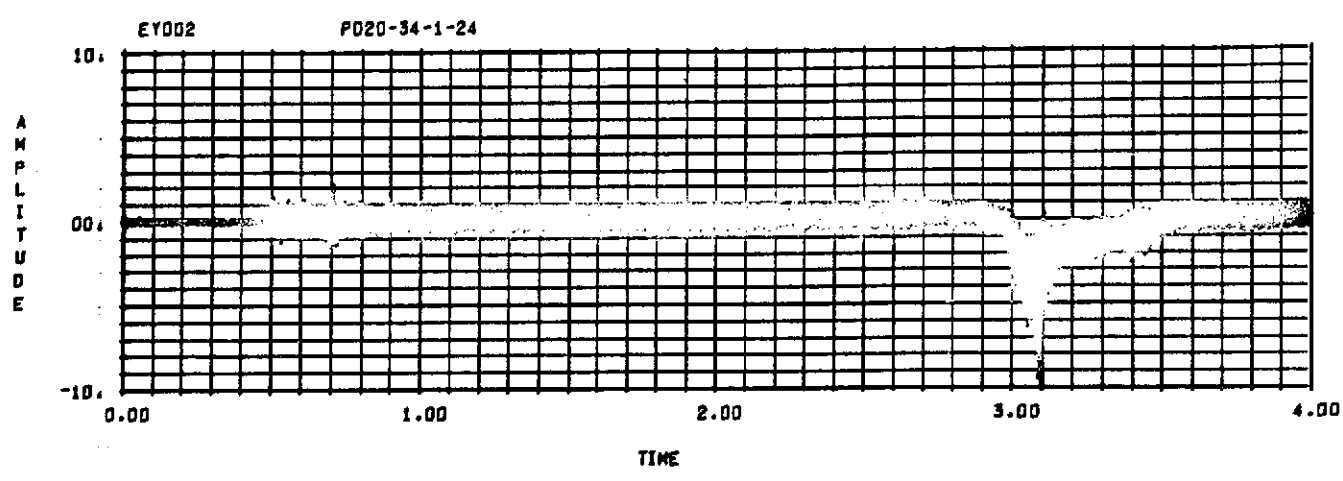
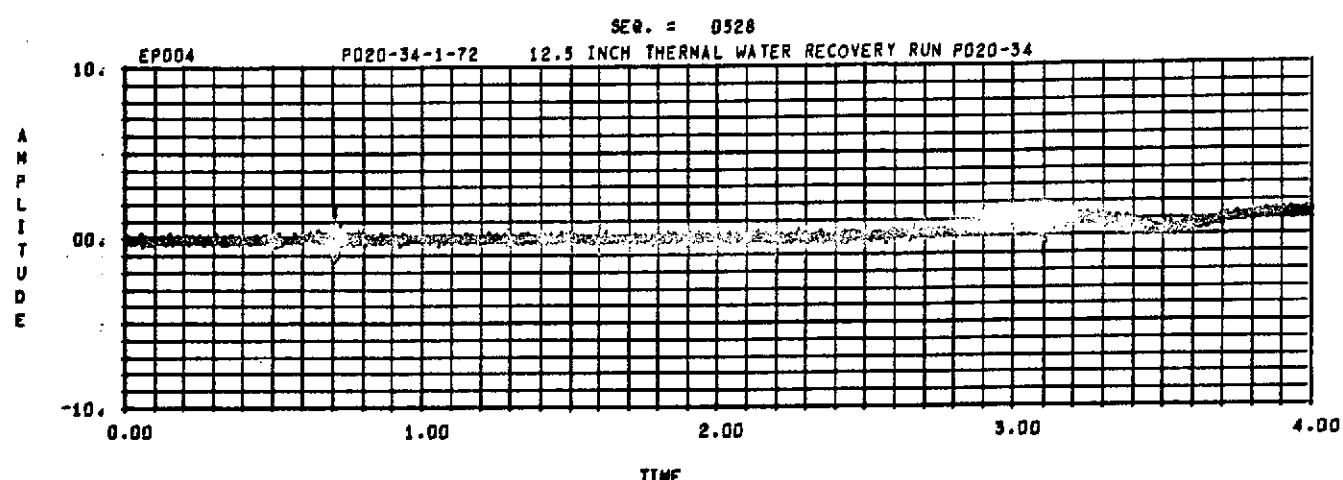




SEQ. = 0528

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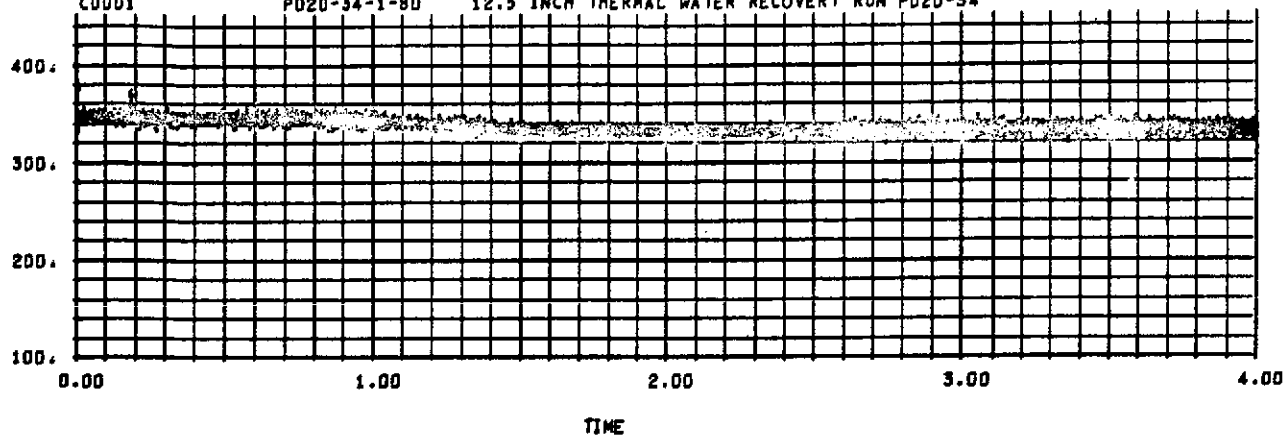


SEQ. = 0528

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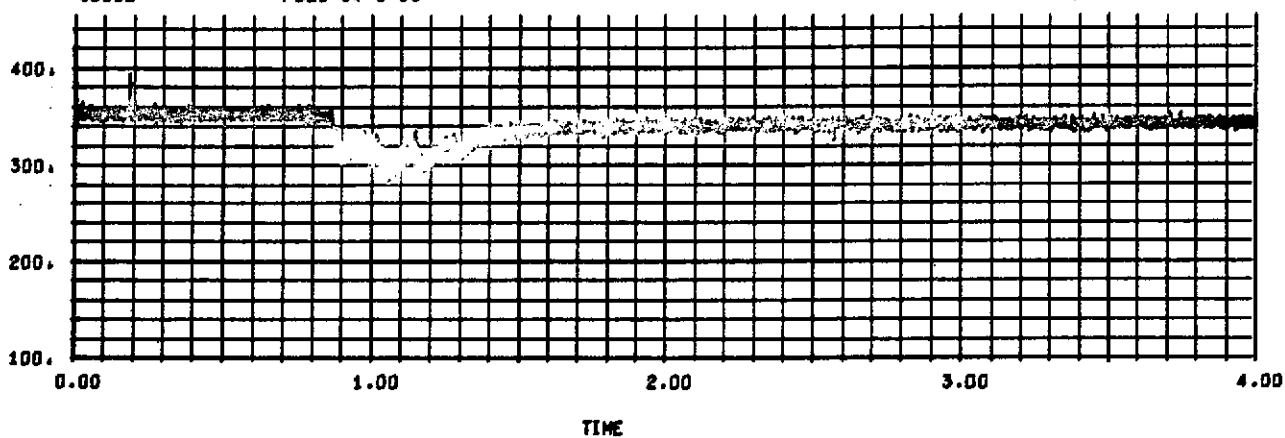
C0001 P020-34-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-34

AMPLITUDE



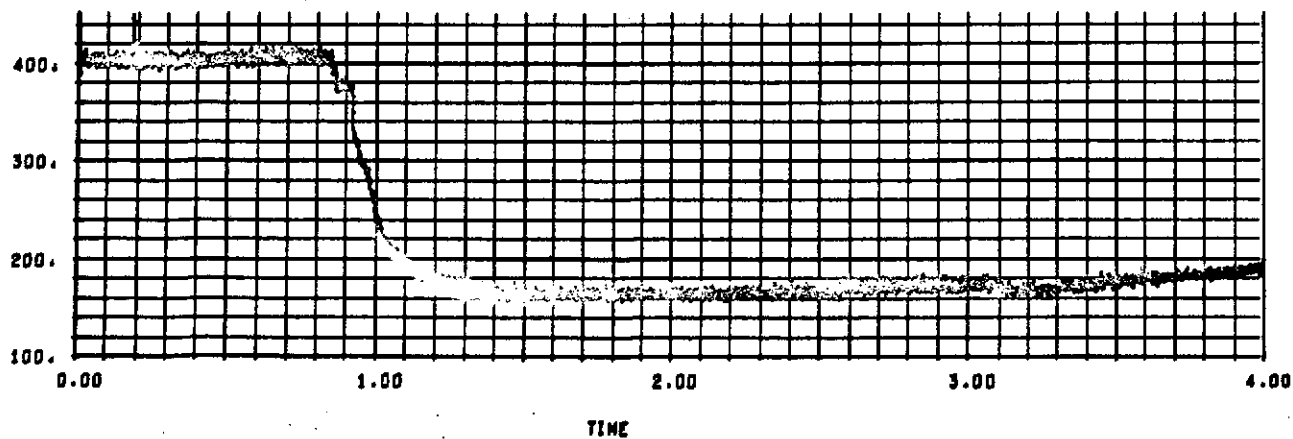
C0002 P020-34-1-88

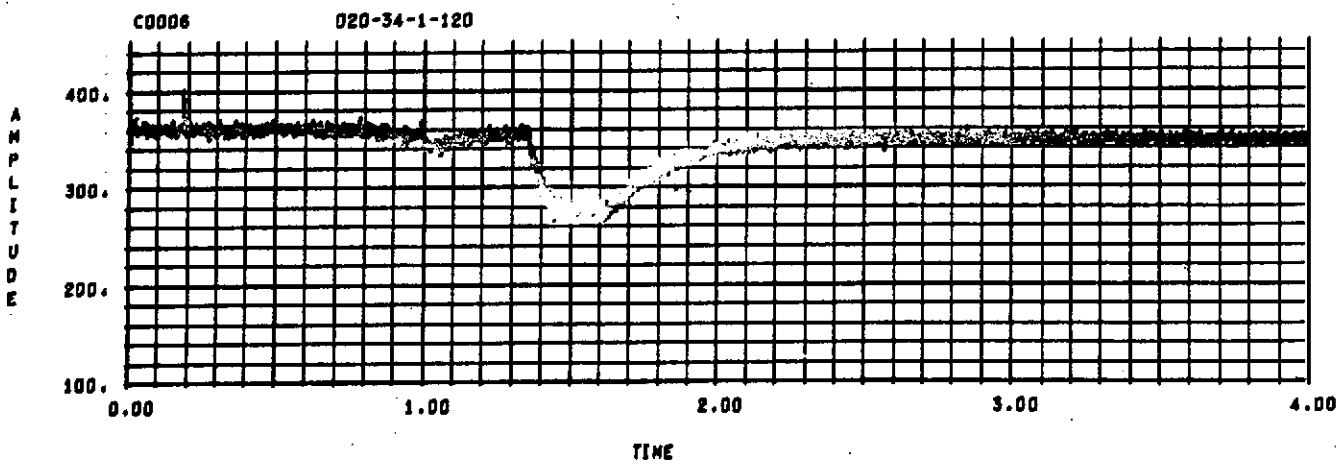
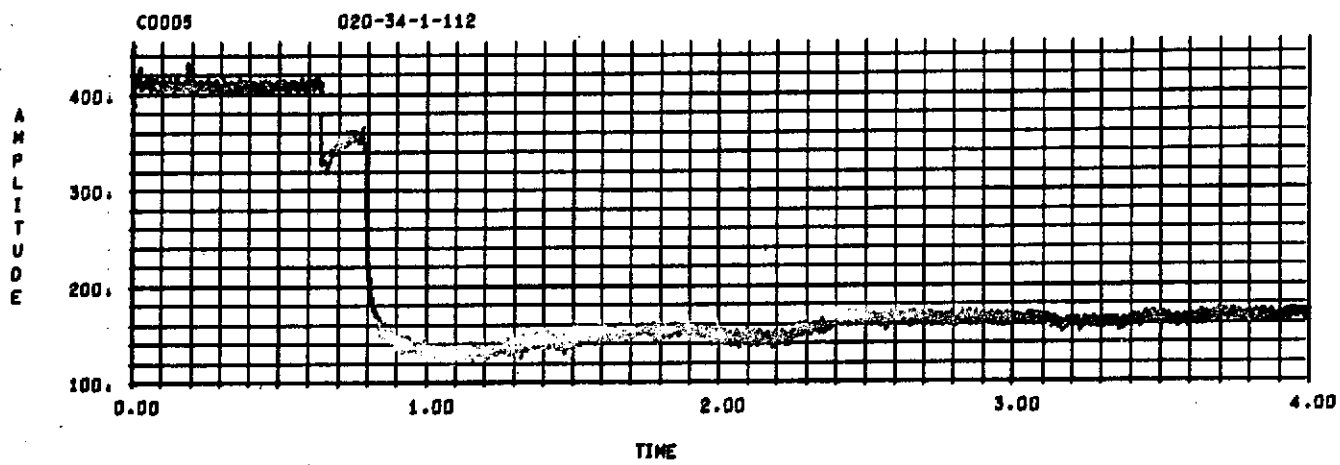
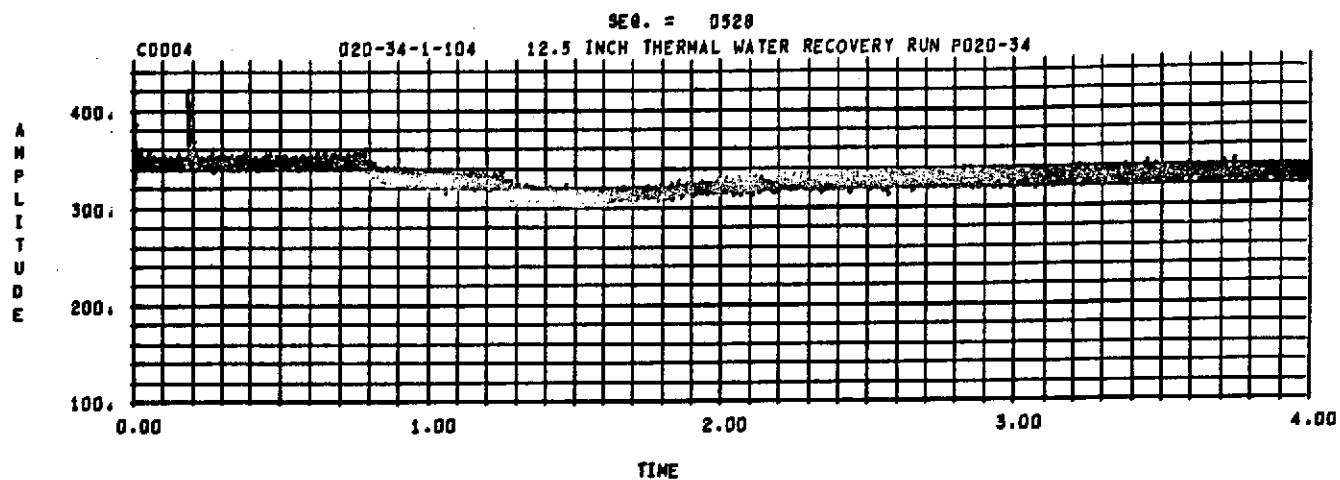
AMPLITUDE

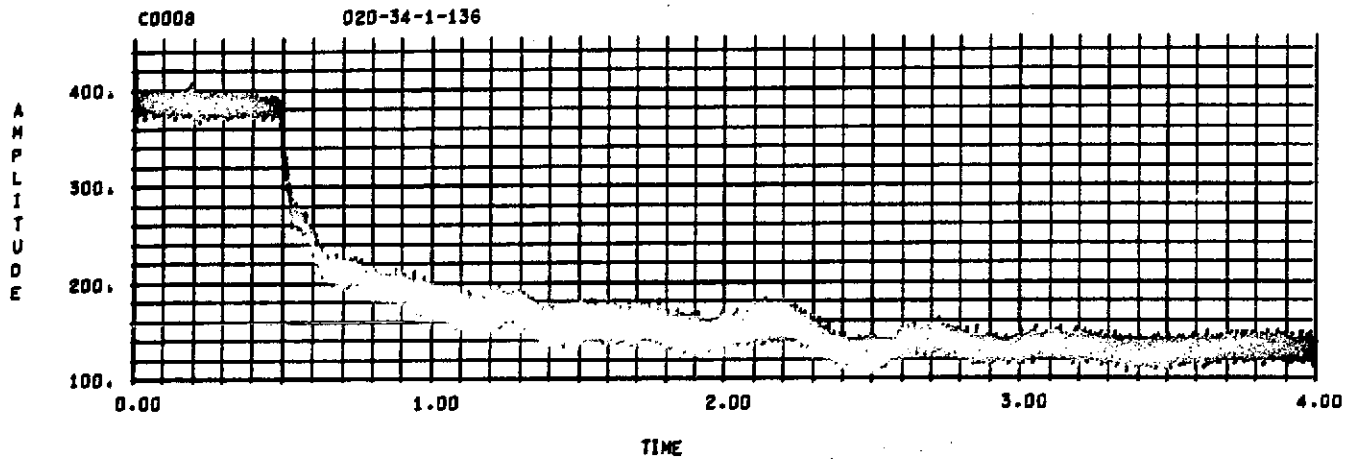


C0003 020-34-1-96

AMPLITUDE

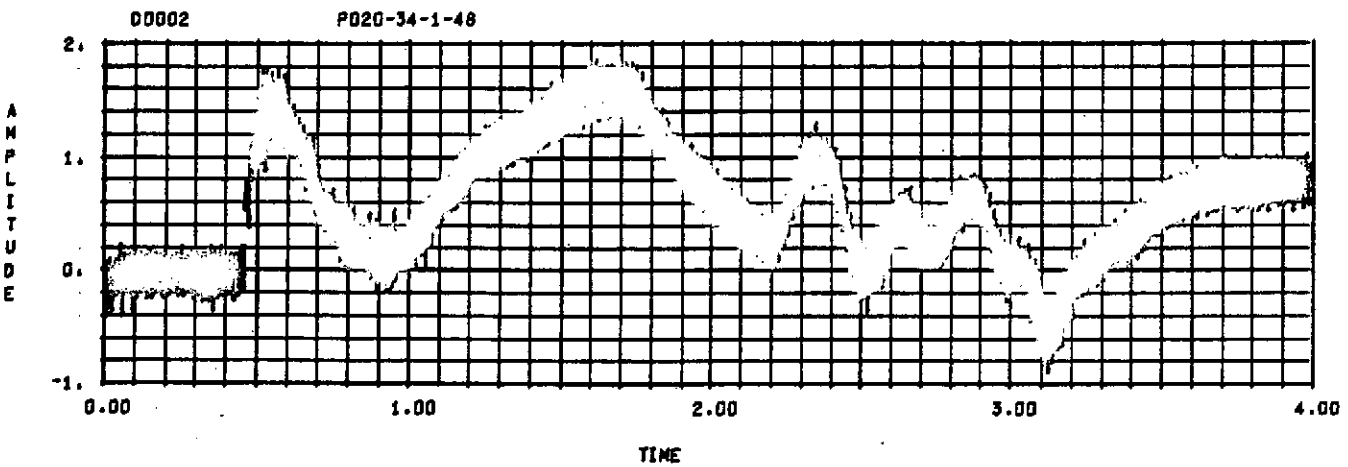
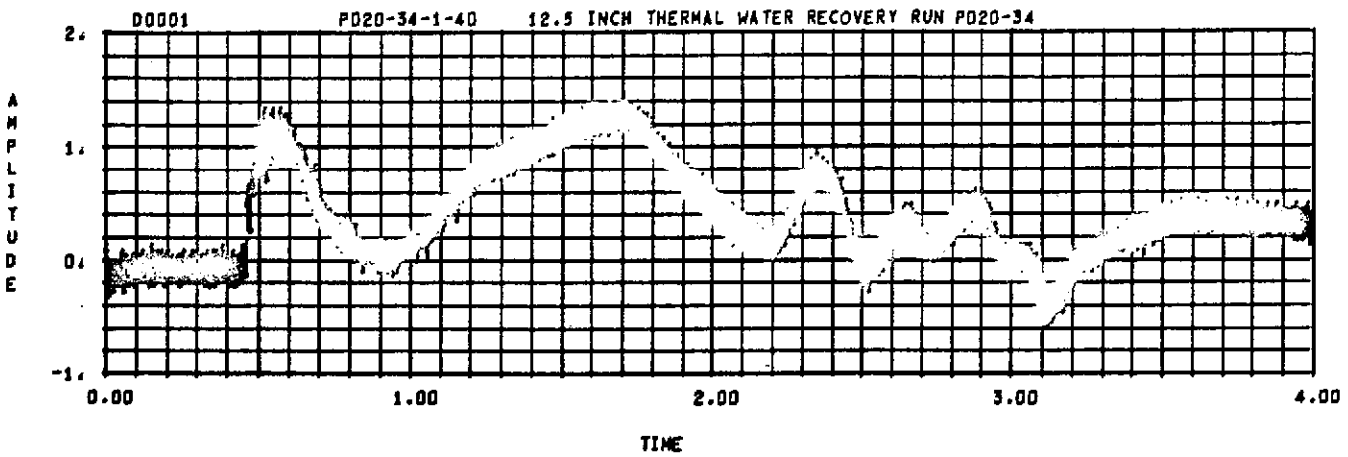






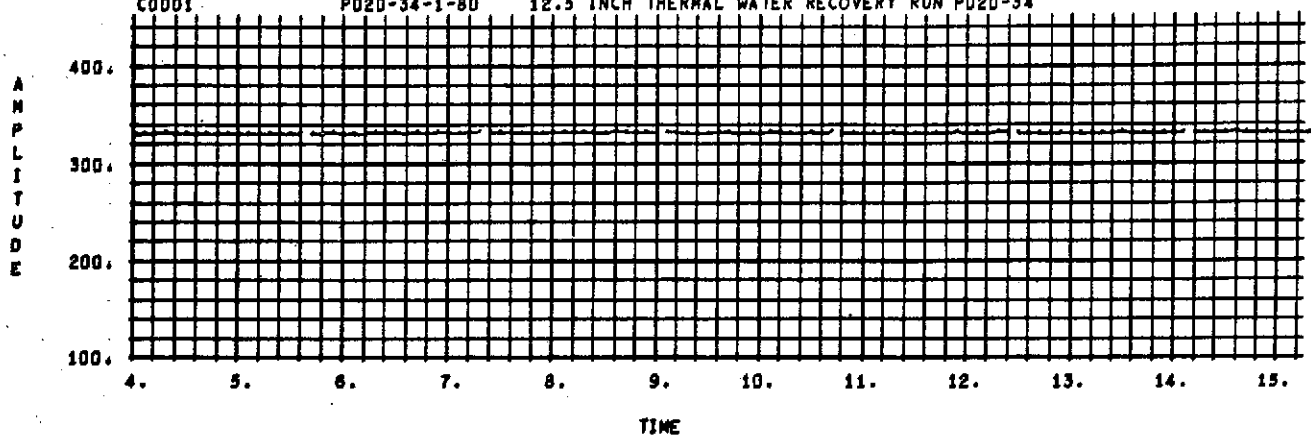
SEQ. = 0528

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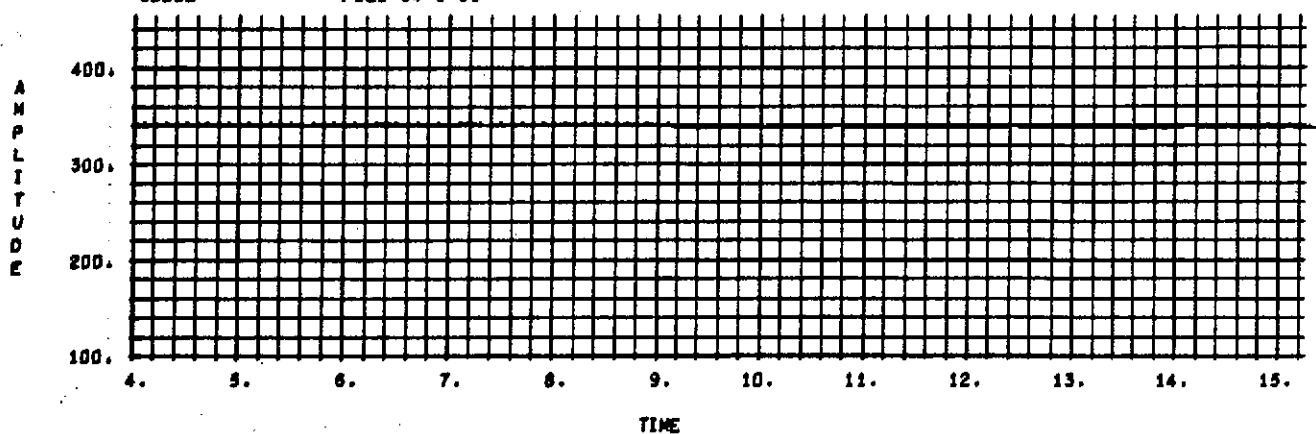


SEQ. = 0528

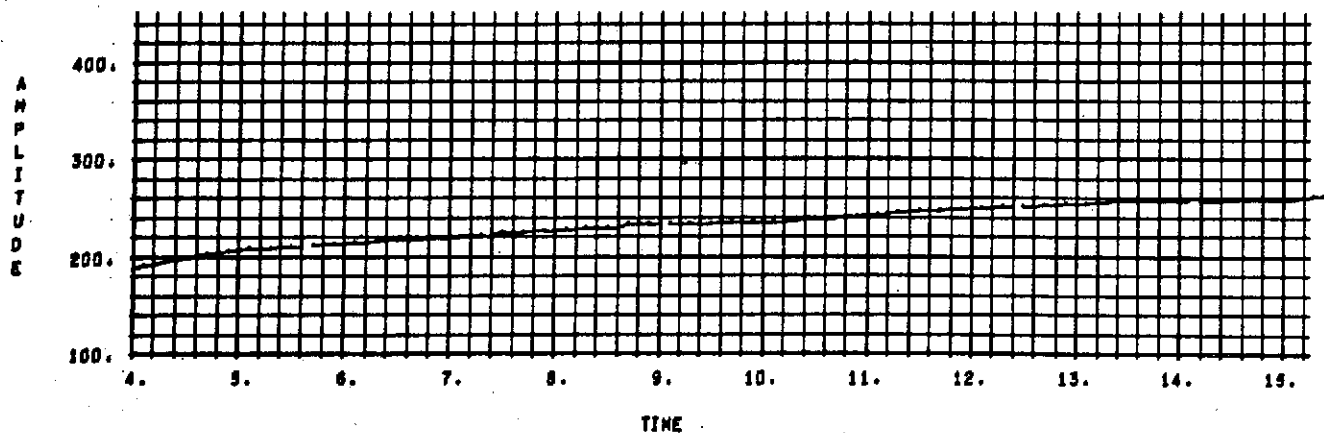
C0001 P020-34-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-34



C0002 P020-34-1-88



C0003 020-34-1-96

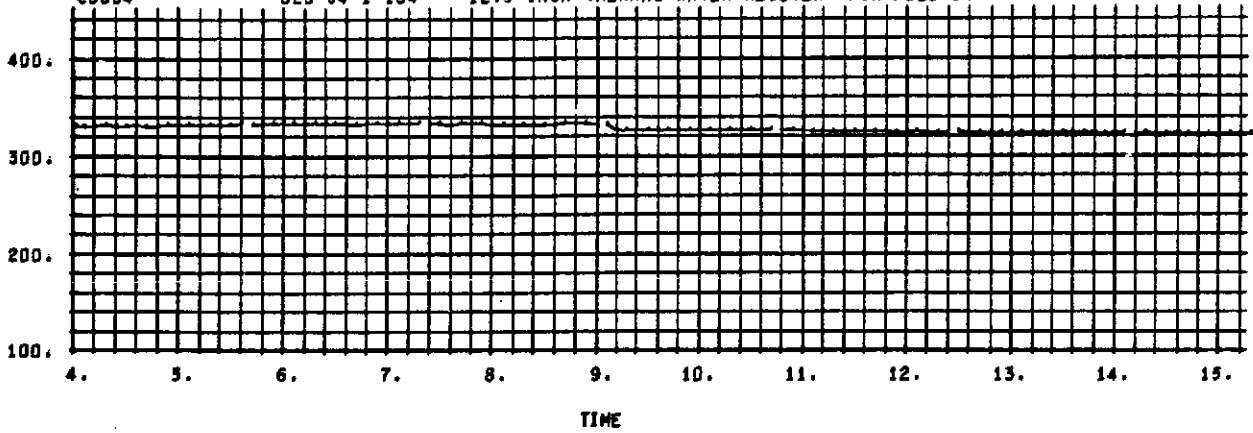


SEQ. = 0528

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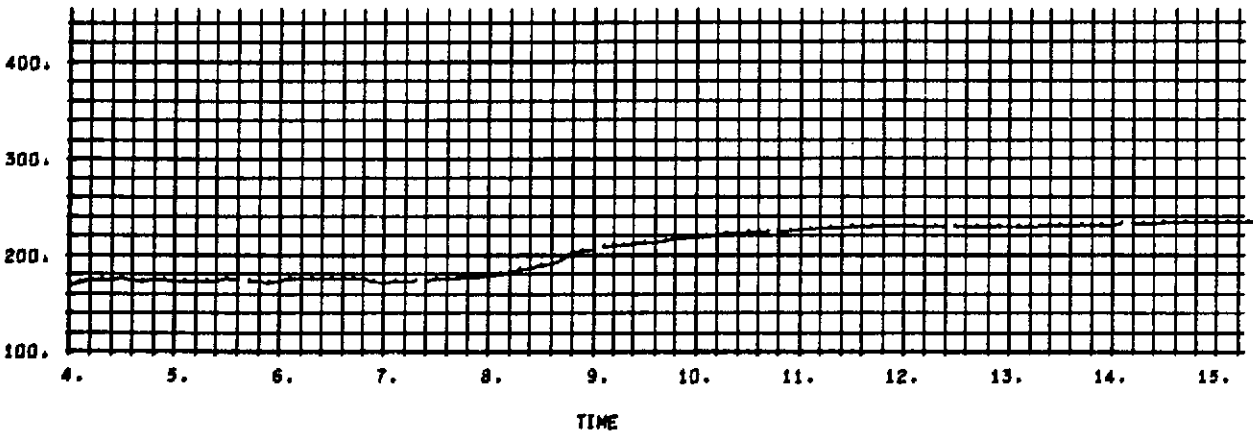
C0004 020-34-1-104 12.5 INCH THERMAL WATER RECOVERY RUN P020-34

AMPLITUDE



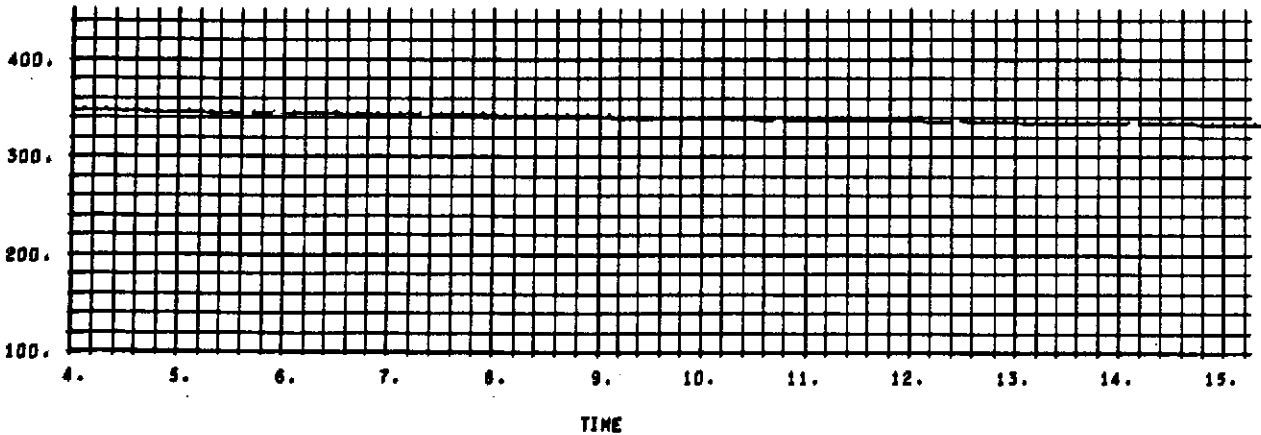
C0005 020-34-1-112

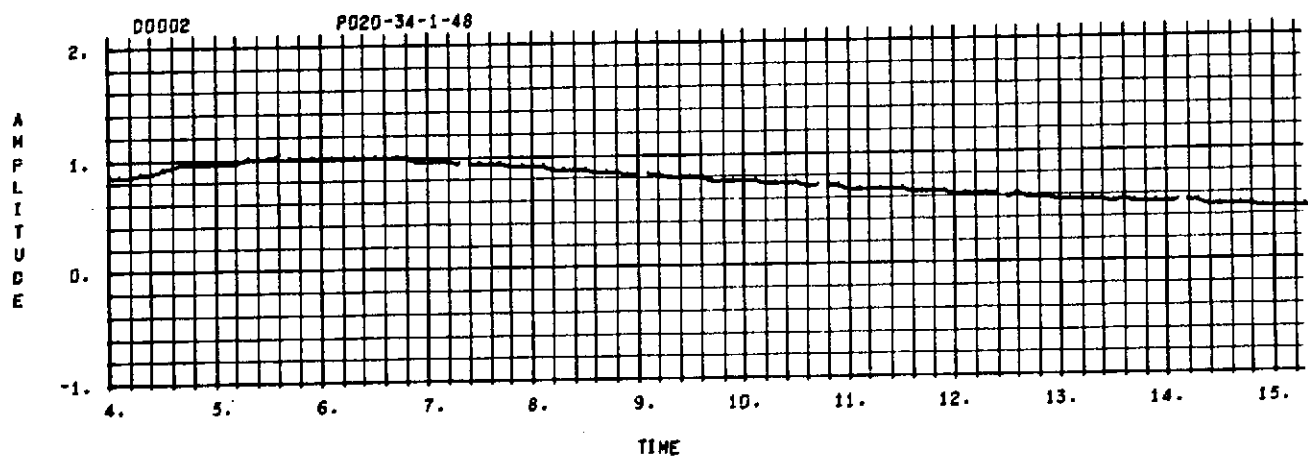
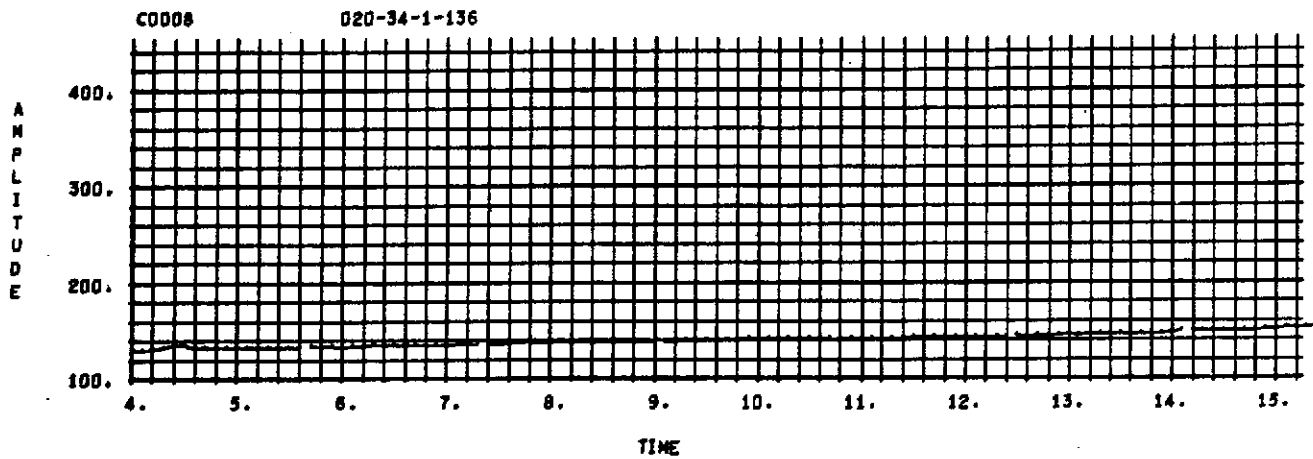
AMPLITUDE



C0006 020-34-1-120

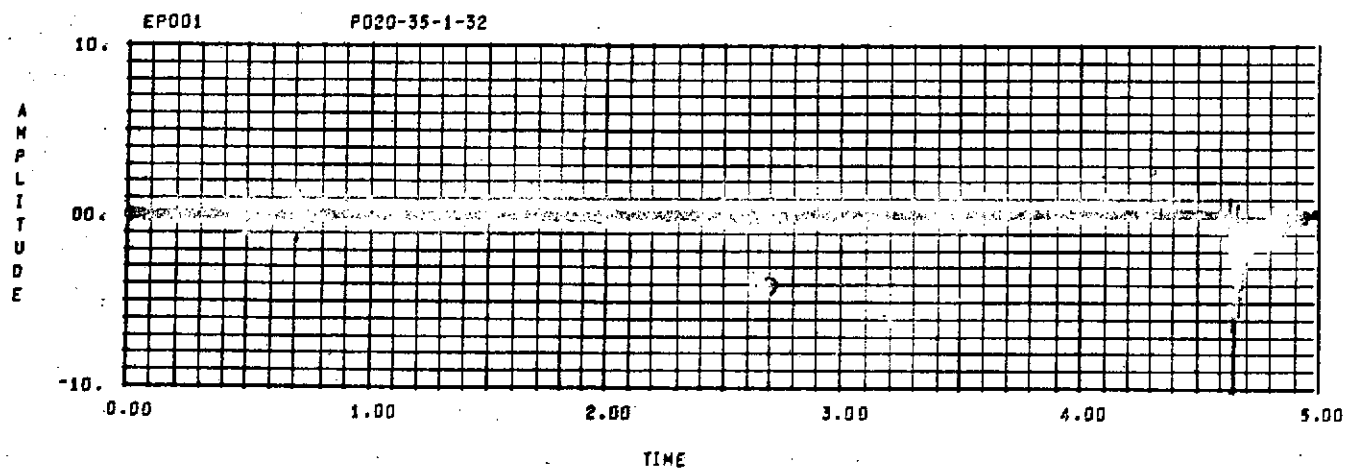
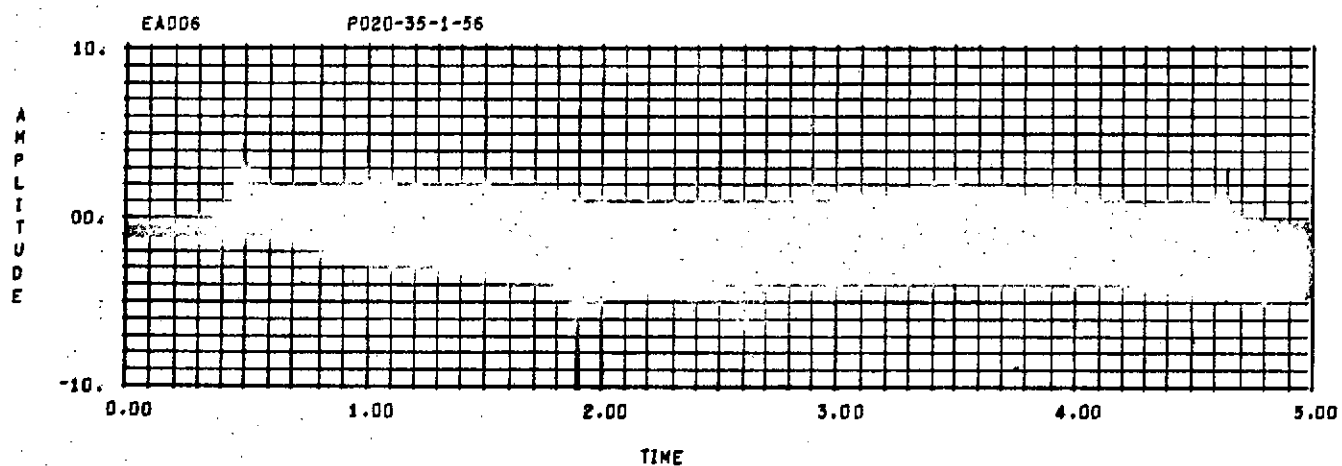
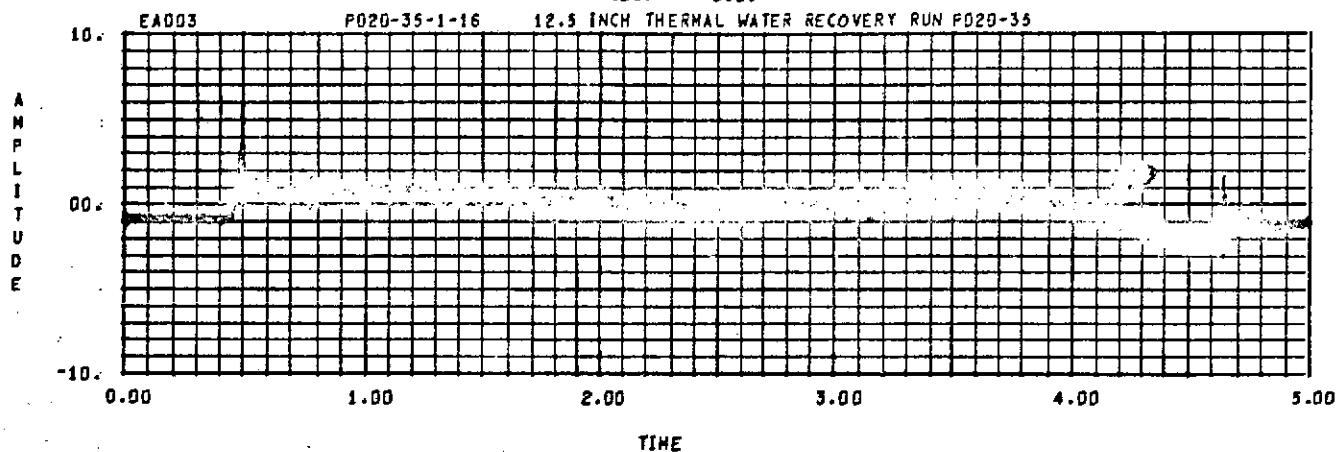
AMPLITUDE

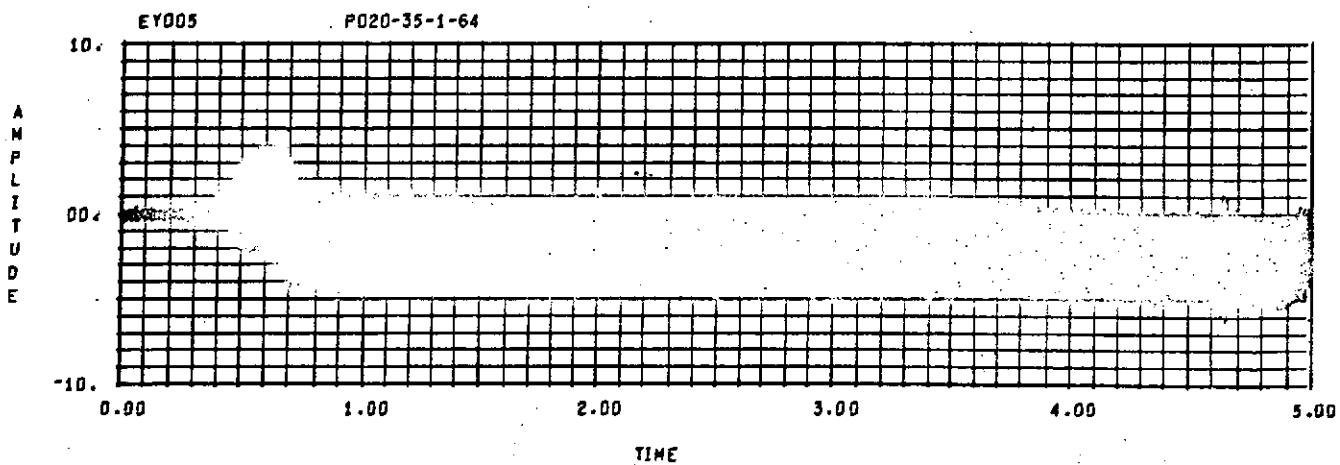
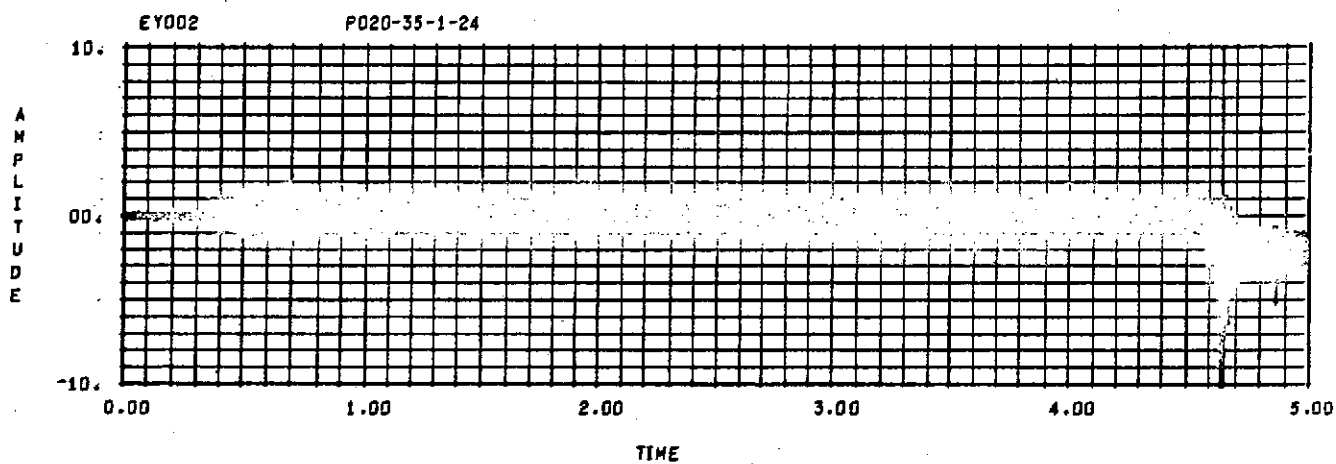
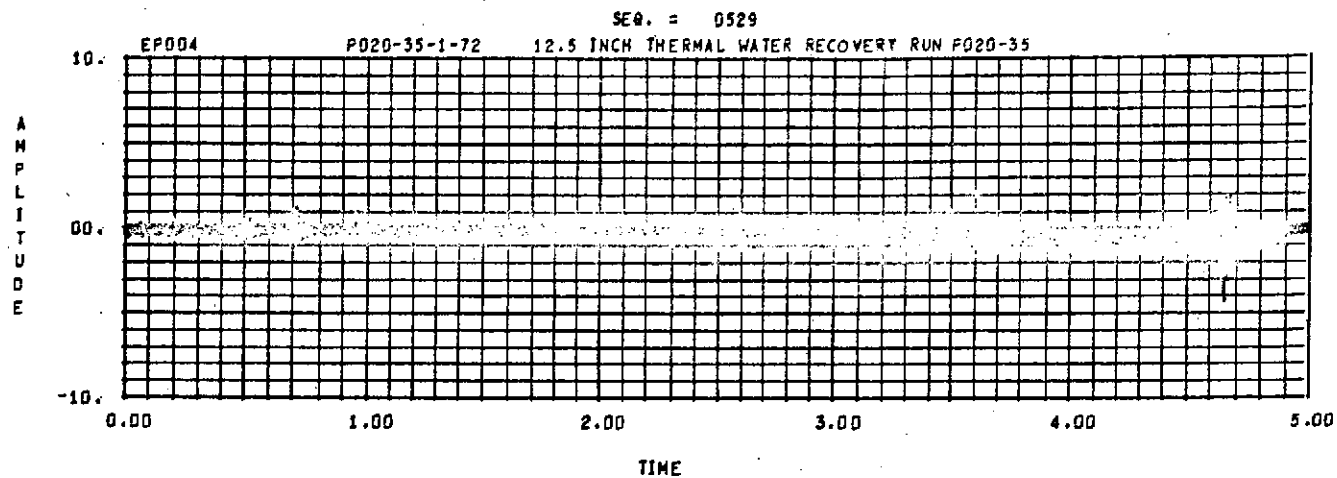




SEQ. = 0529

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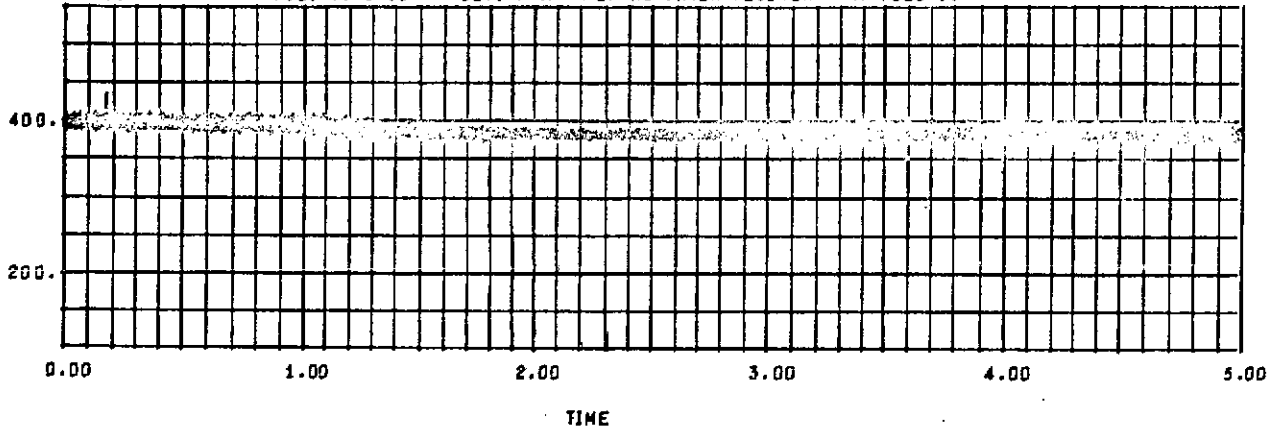


SEQ. = 0529

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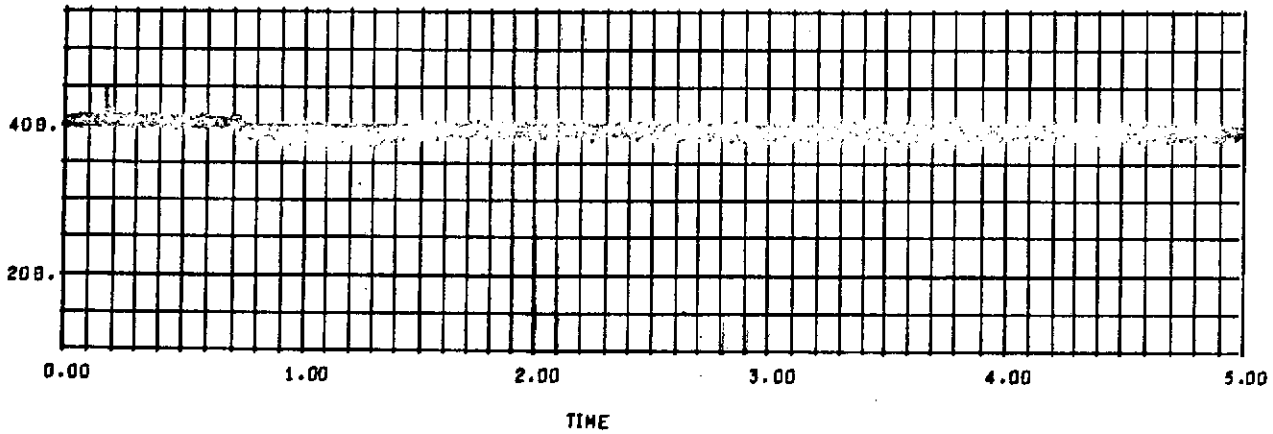
C0001 P020-35-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-35

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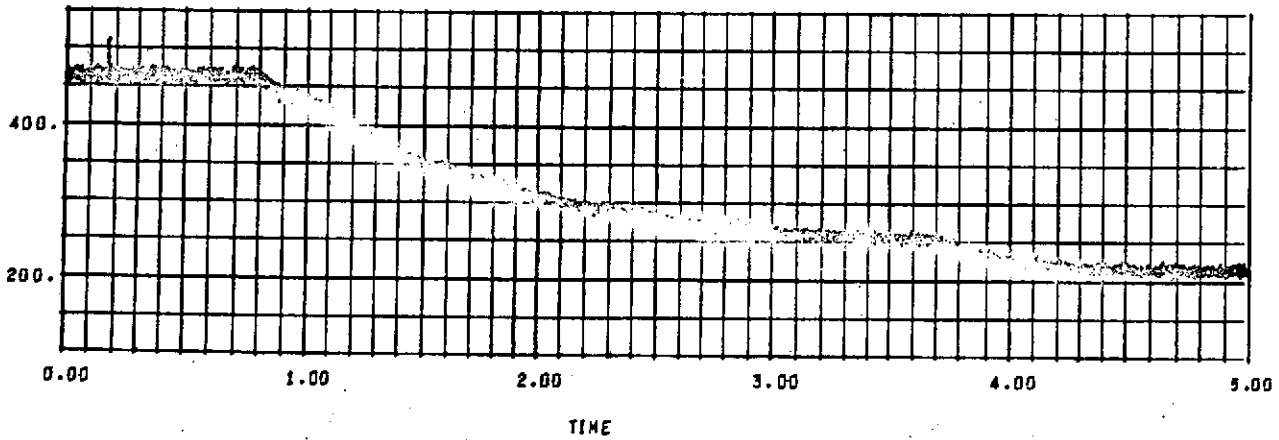
C0002 P020-35-1-88

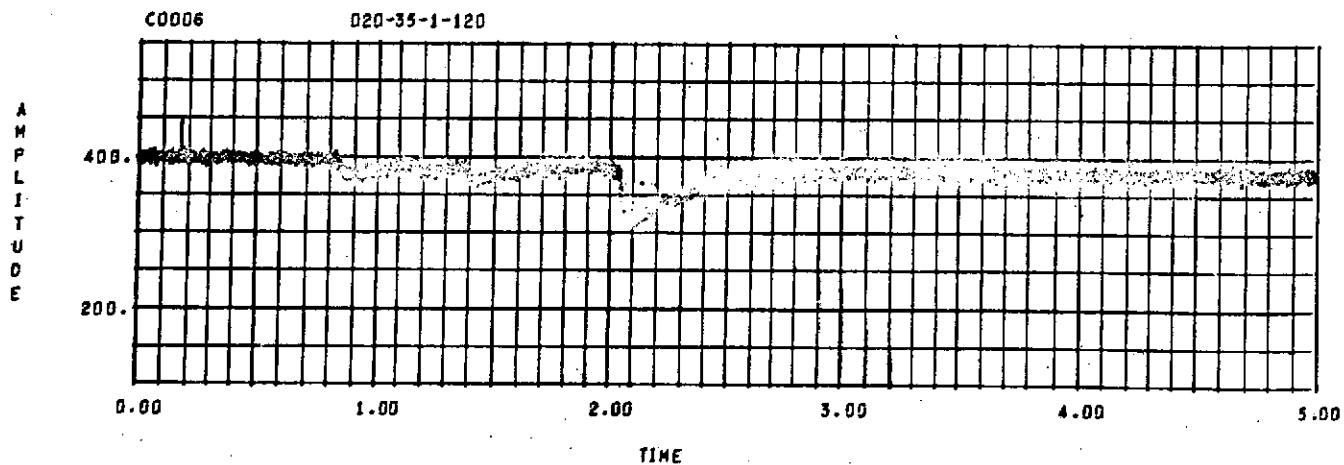
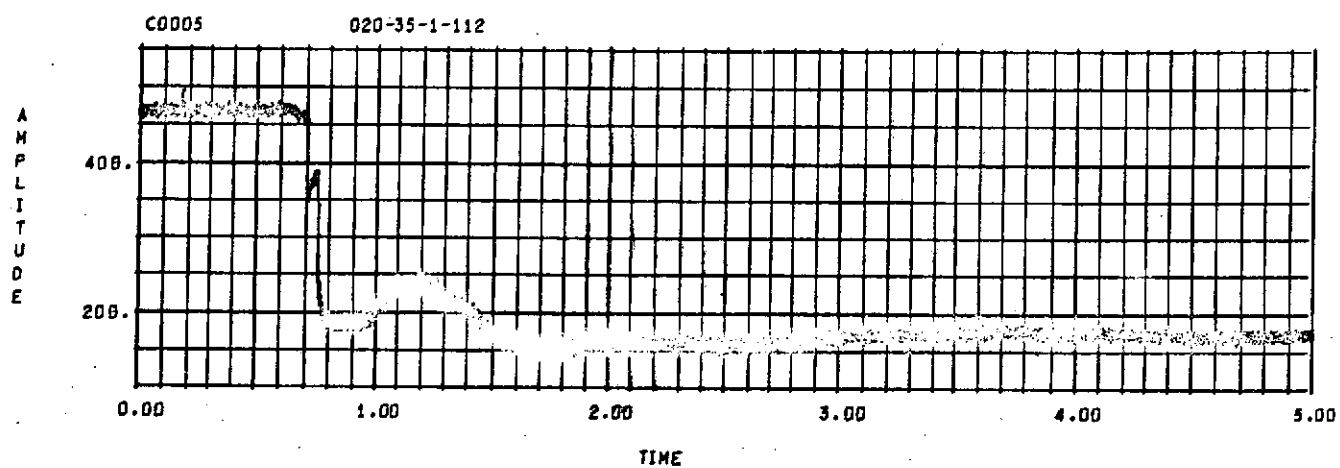
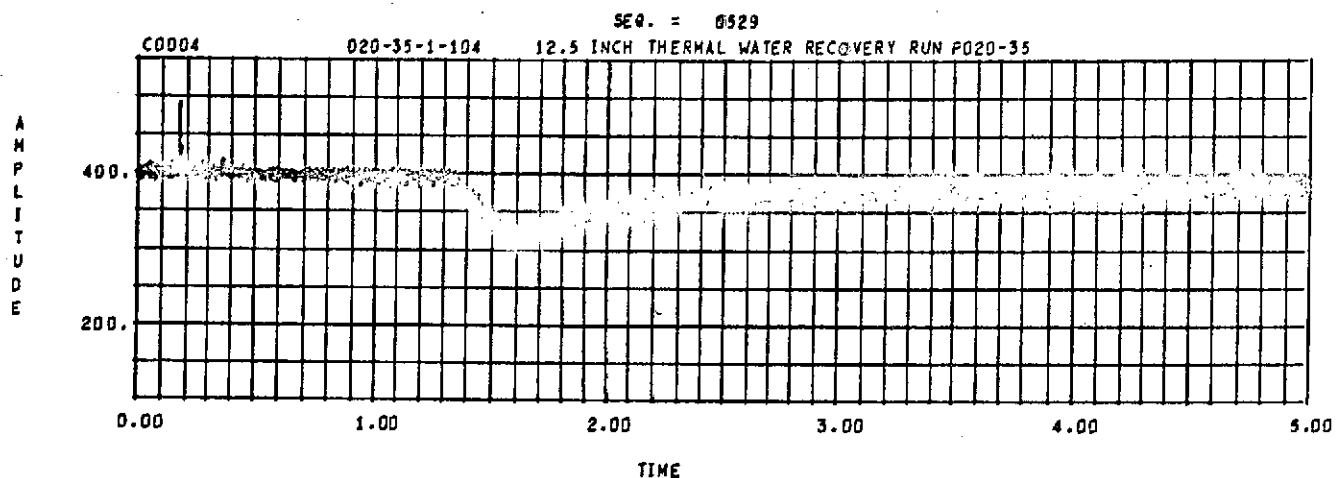
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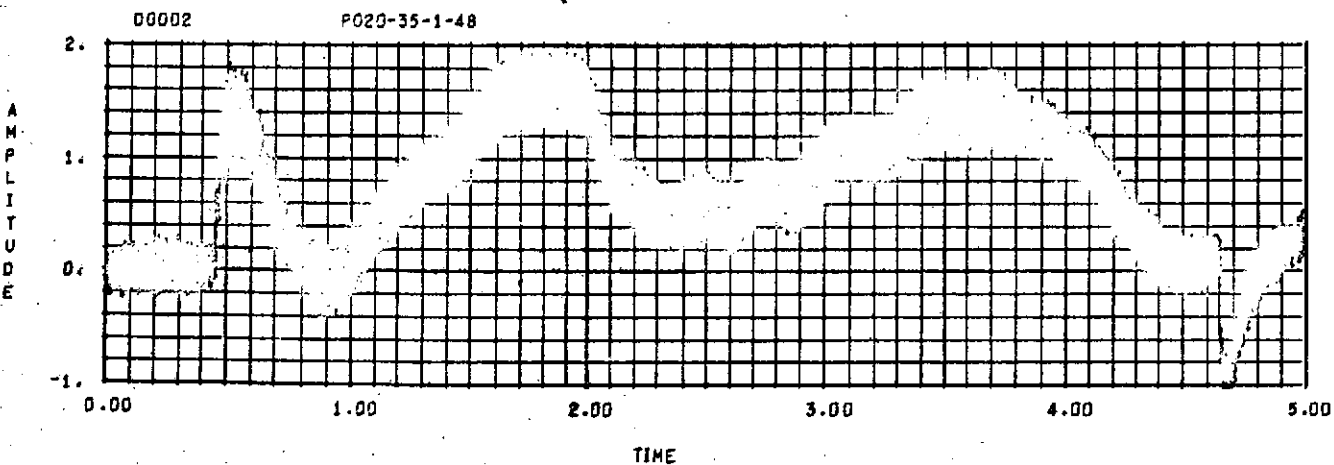
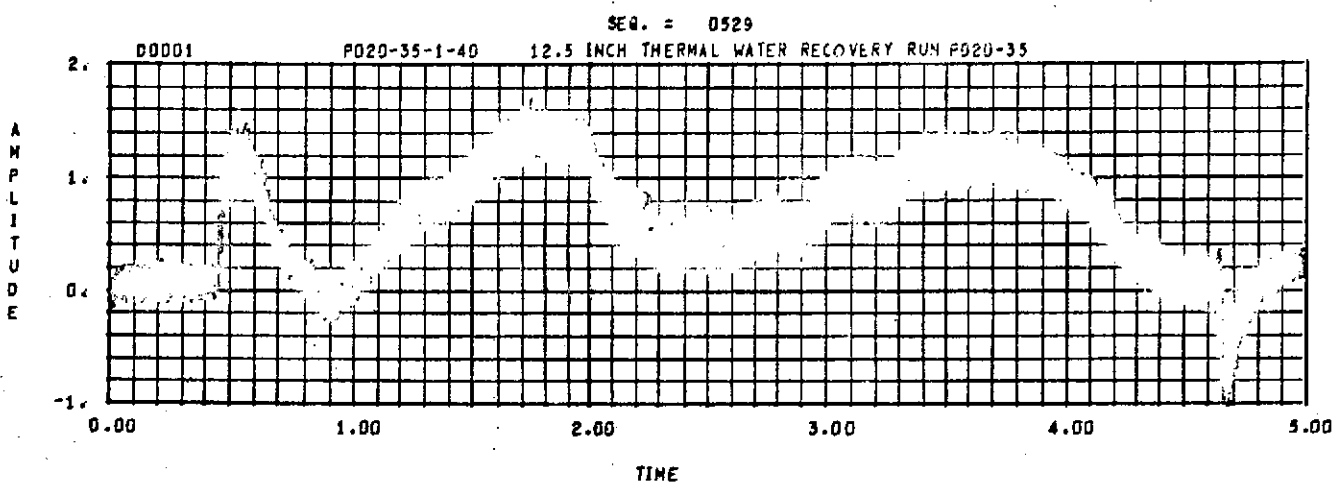
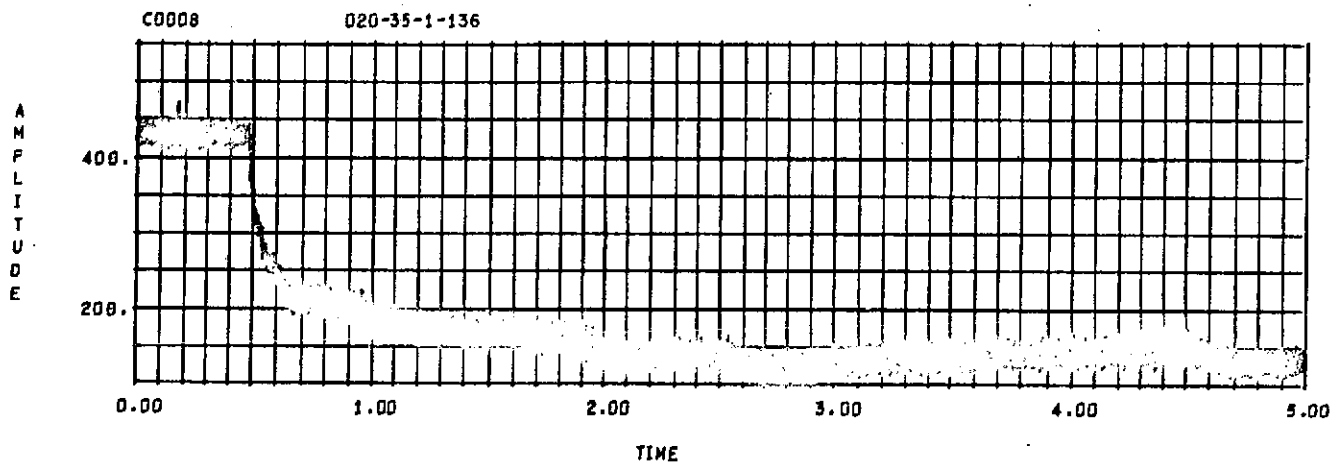


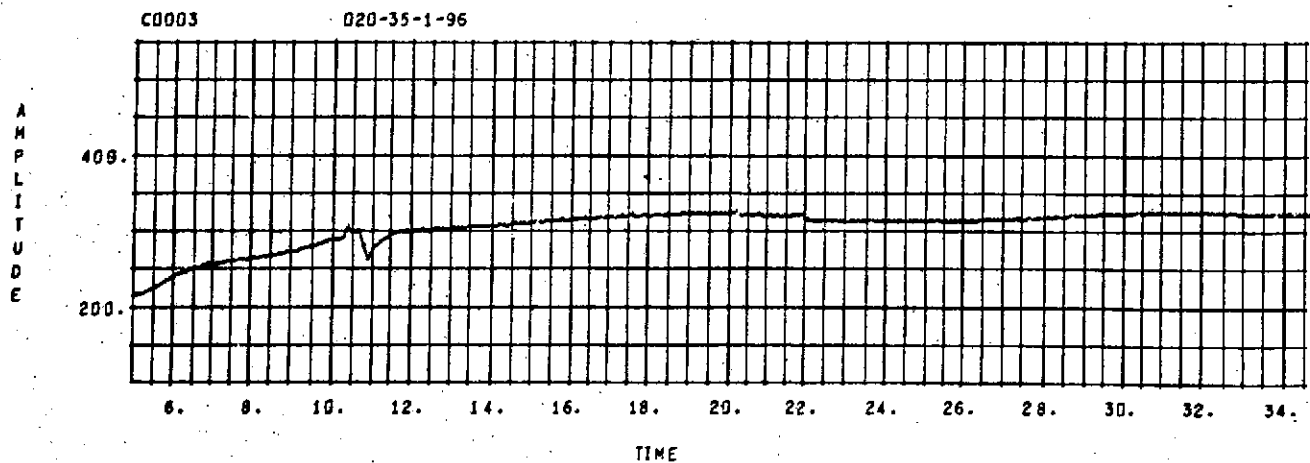
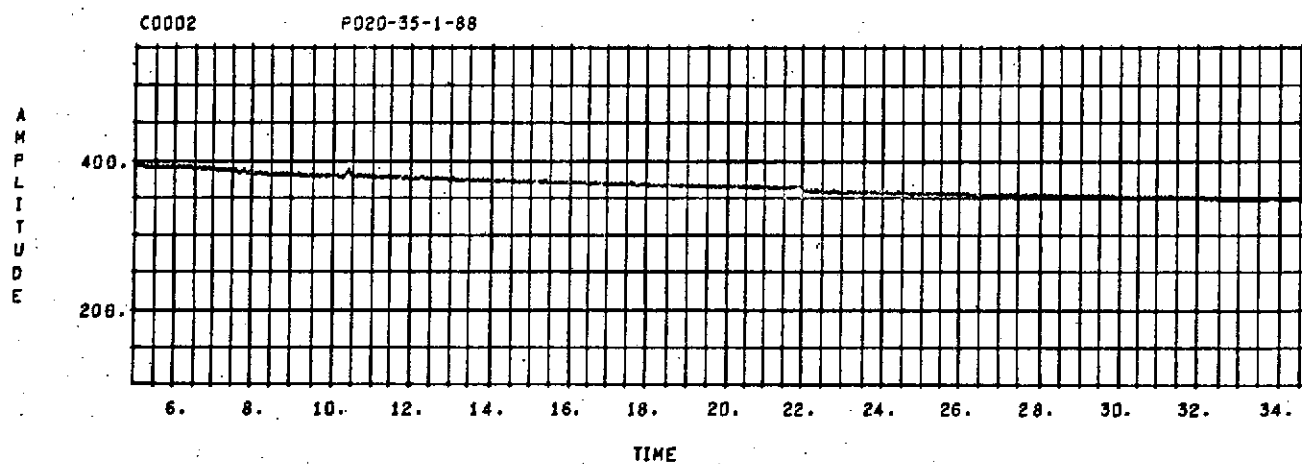
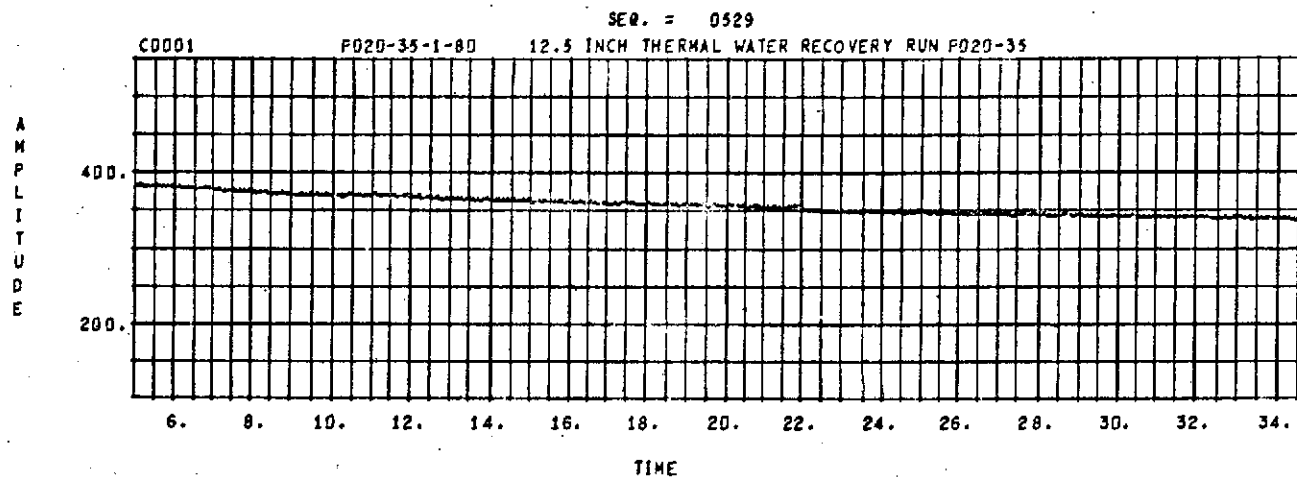
C0003 020-35-1-96

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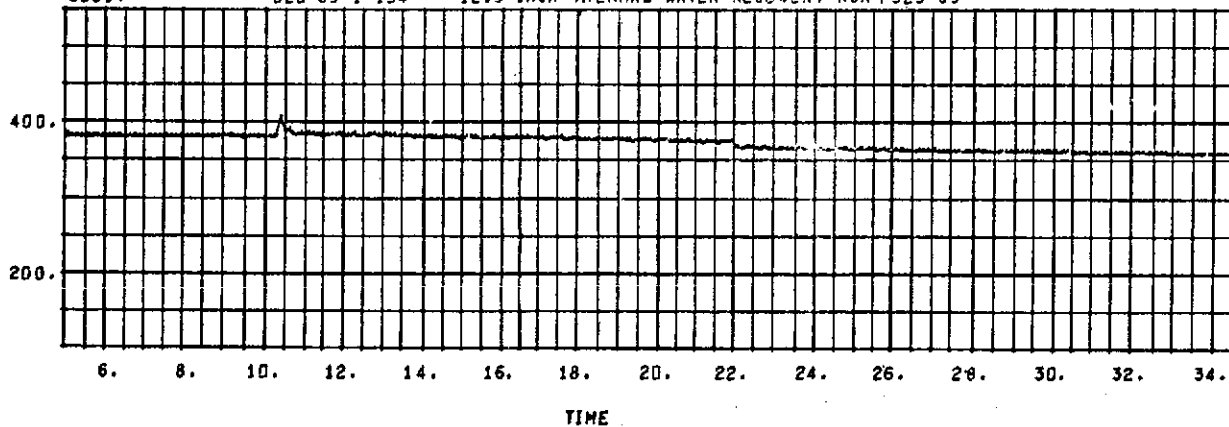


SEQ. = 0529

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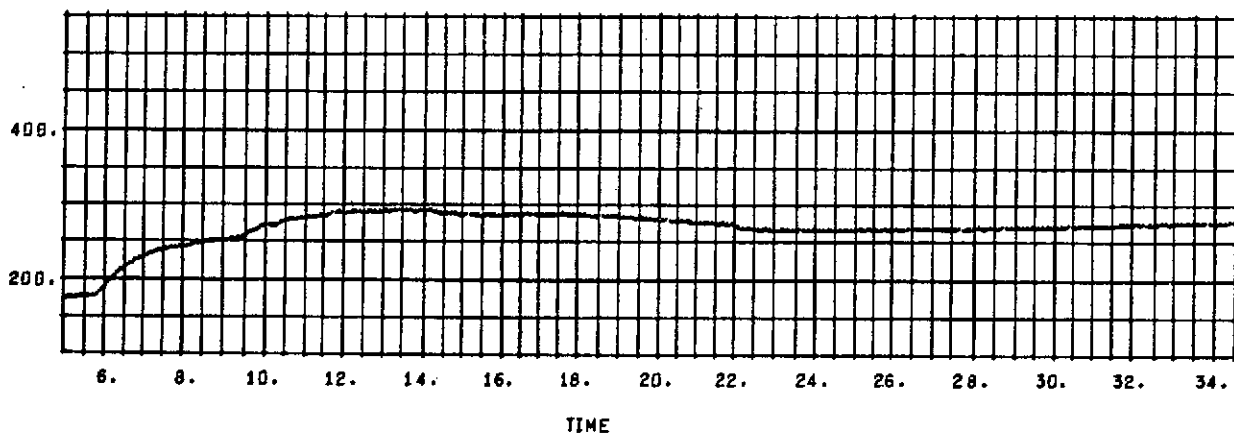
C0004 020-35-1-104 12.5 INCH THERMAL WATER RECOVERY RUN P020-35

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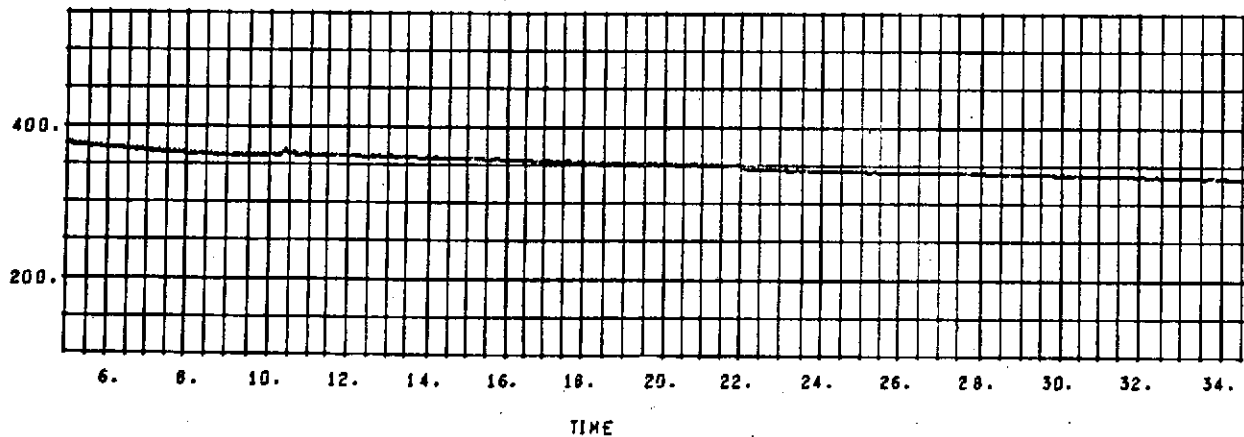
C0005 020-35-1-112

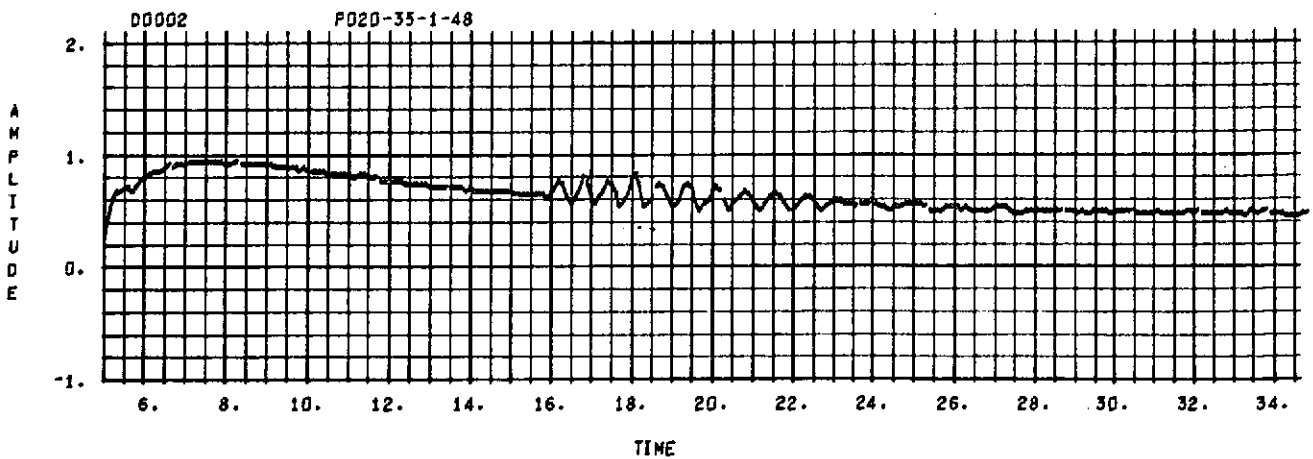
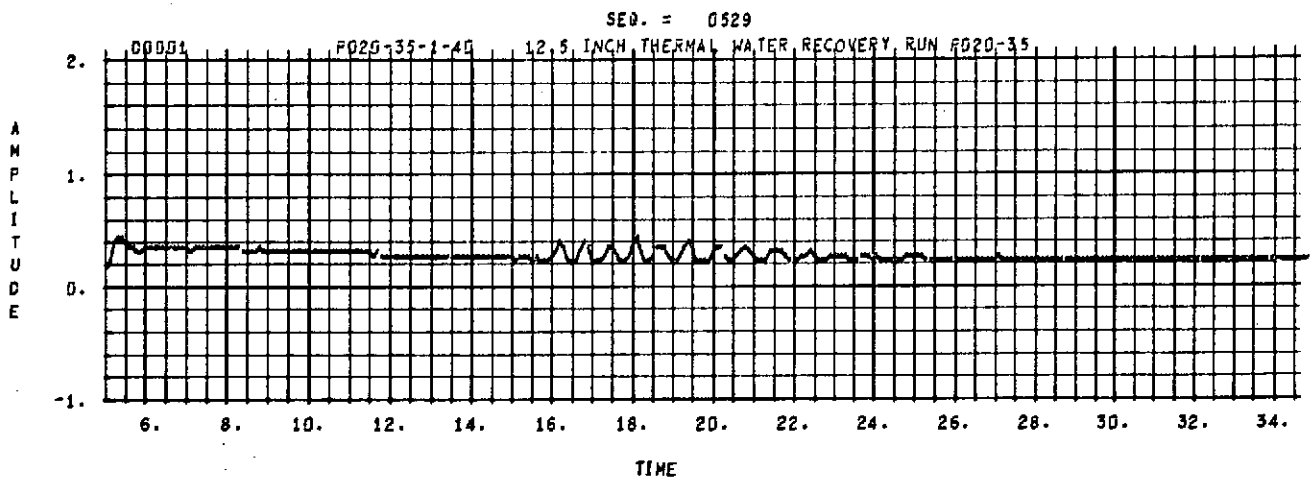
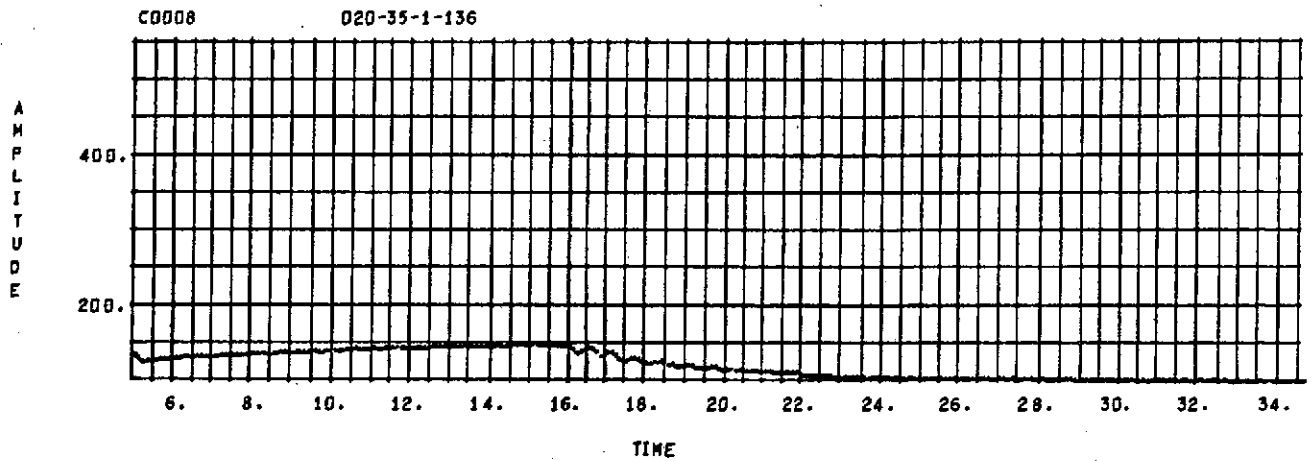
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C0006 020-35-1-120

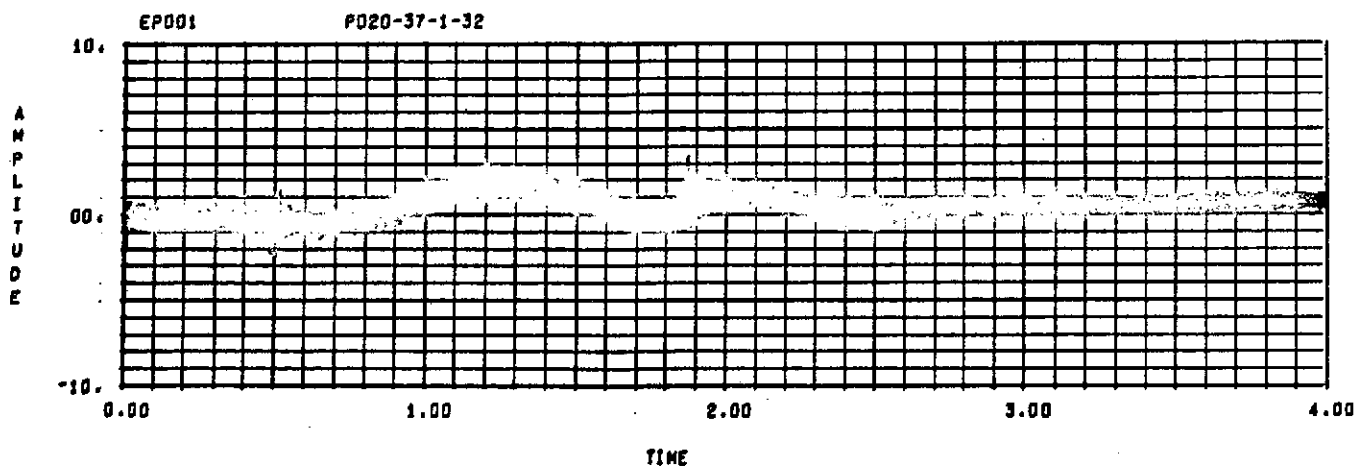
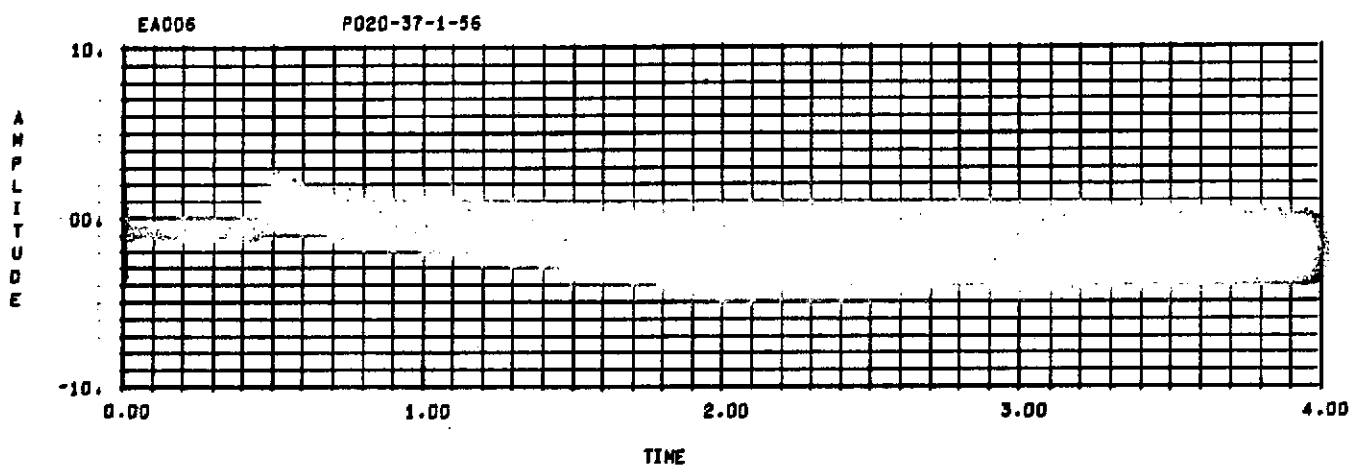
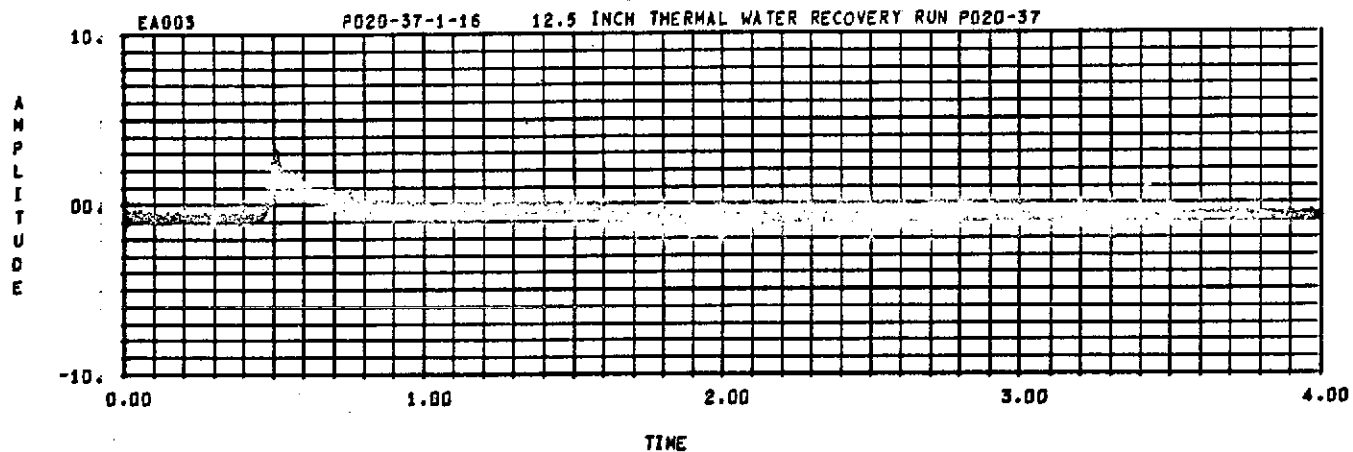
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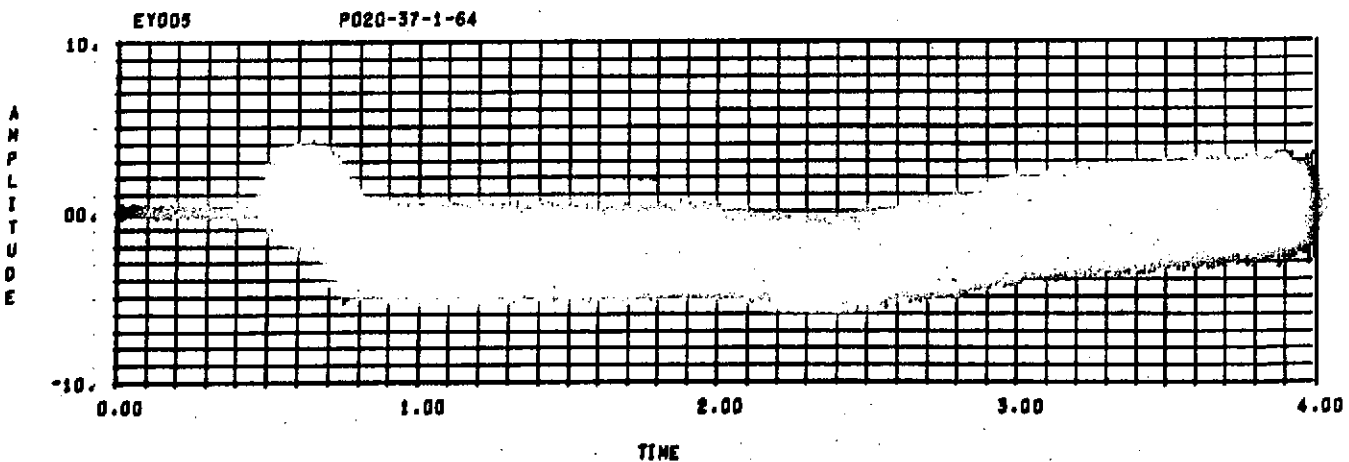
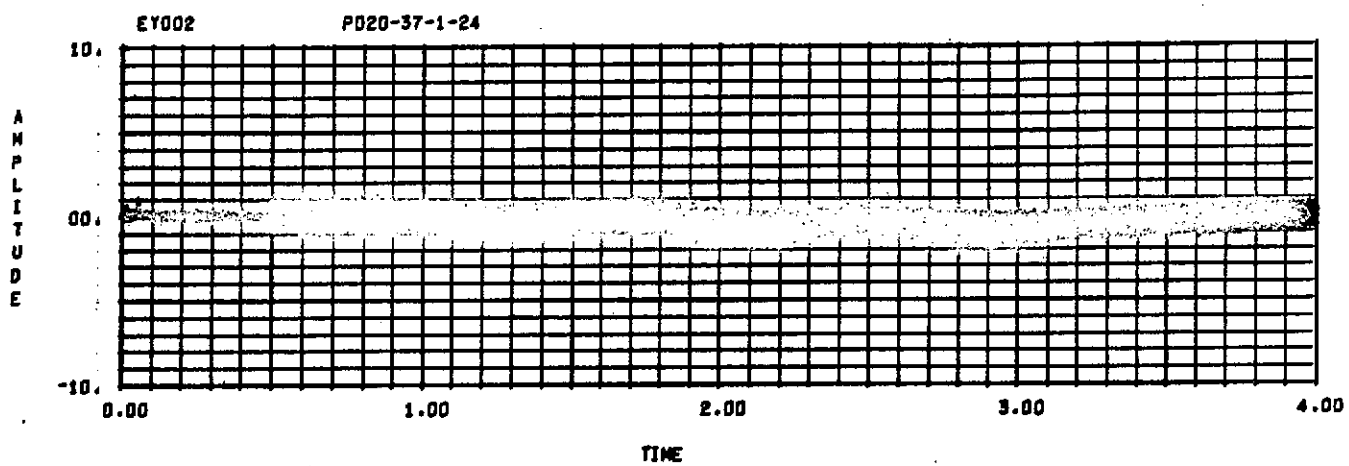
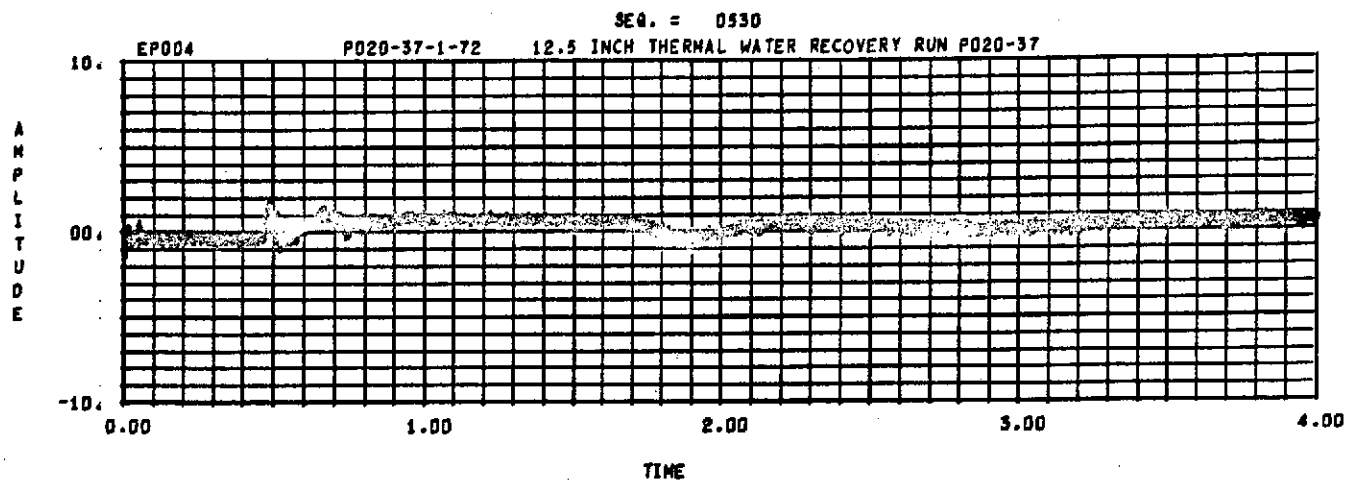




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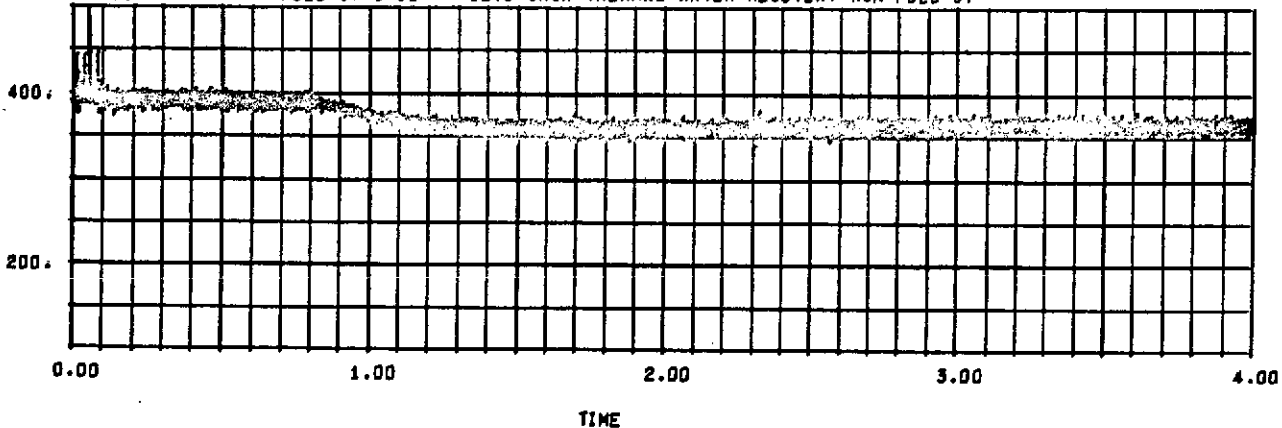


SEQ. = 0530

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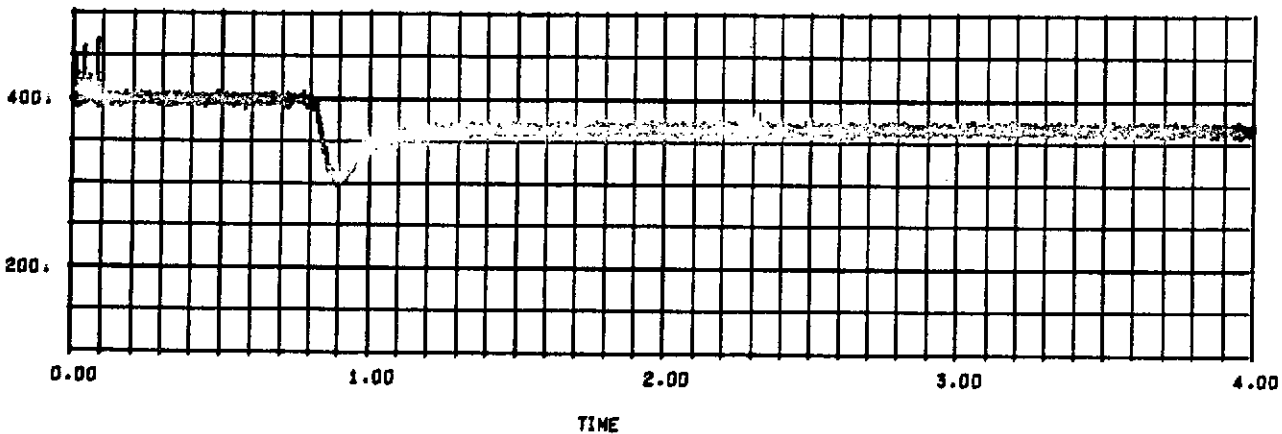
C0001 P020-37-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-37

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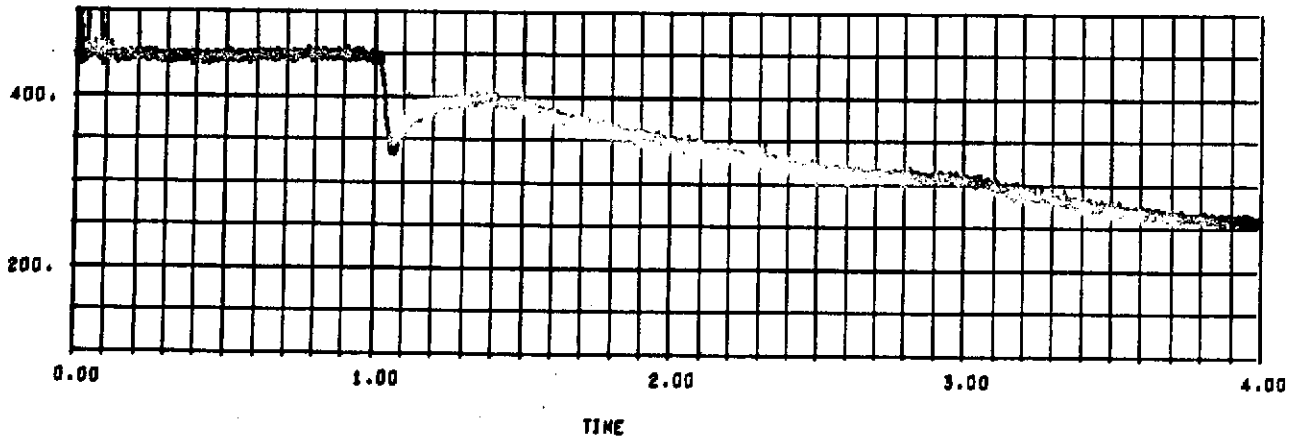
C0002 P020-37-1-88

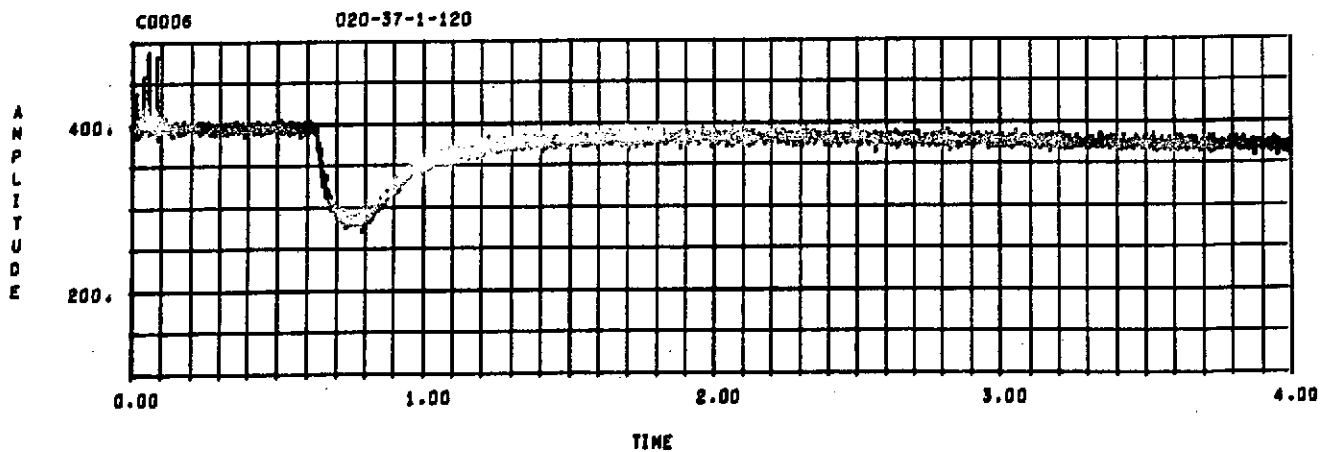
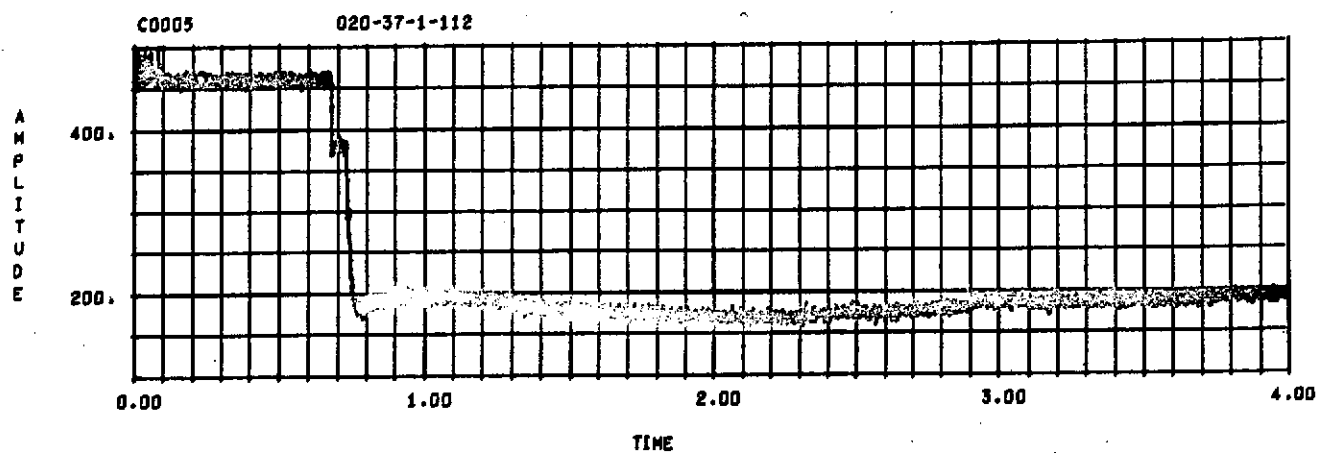
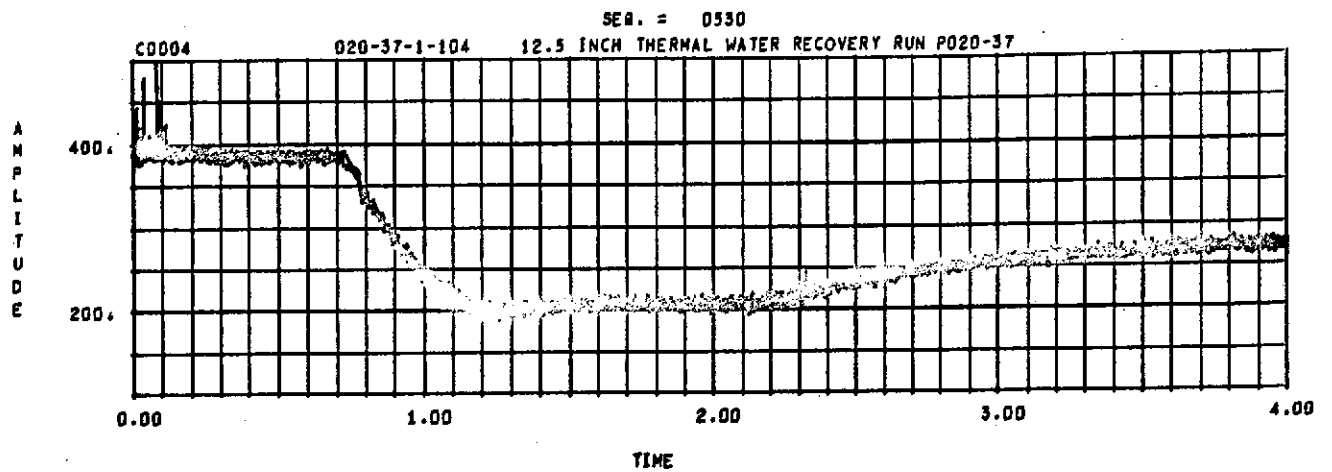
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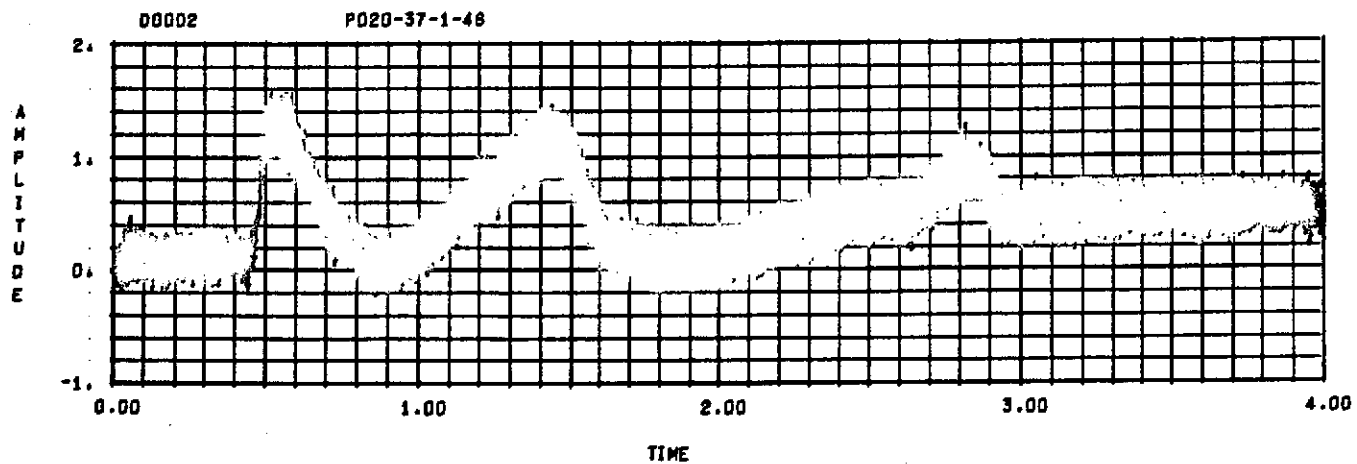
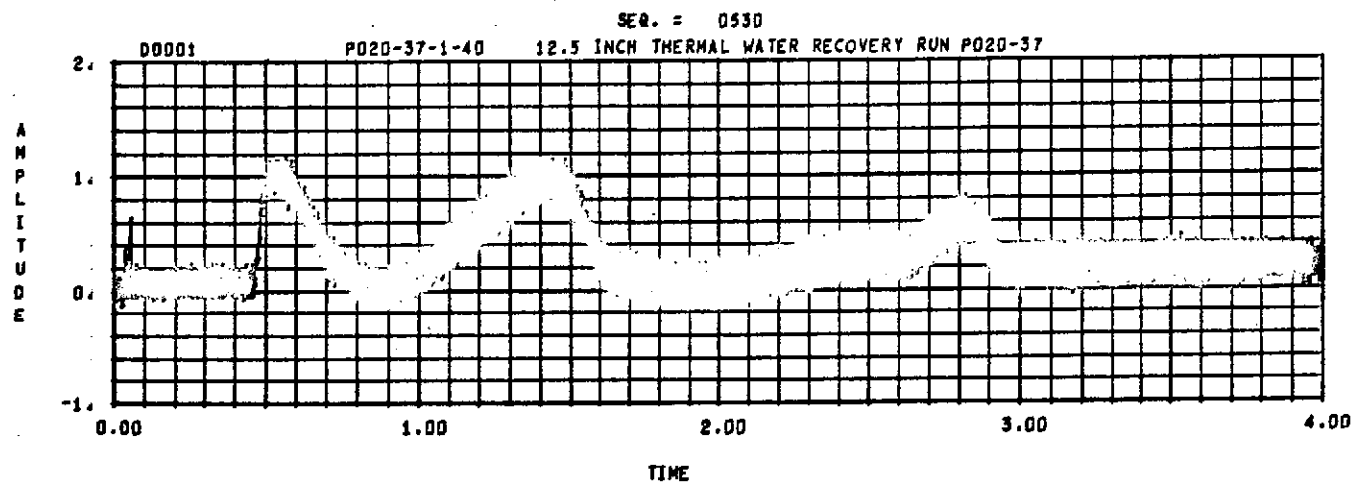
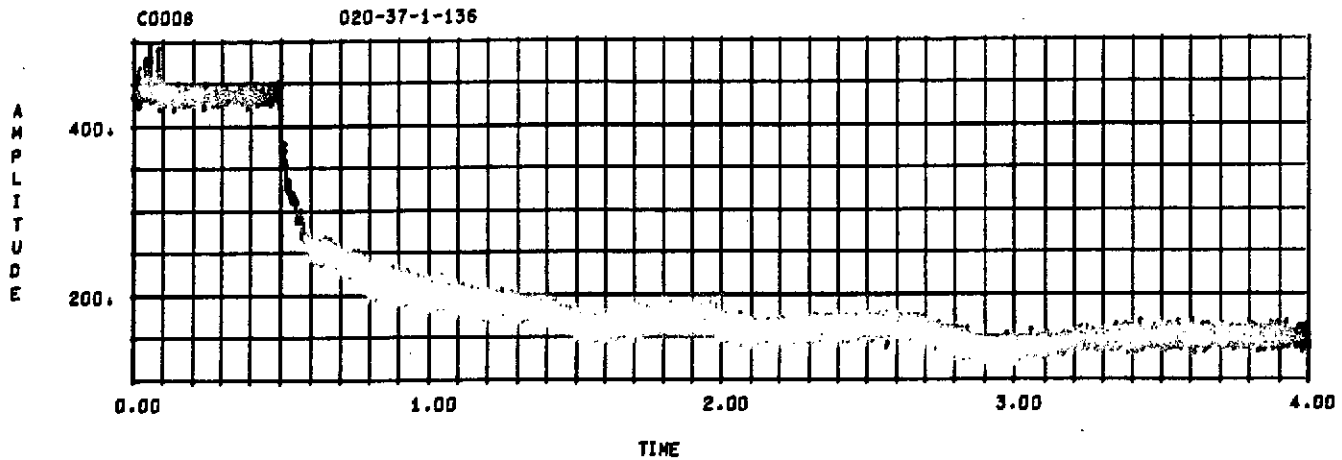


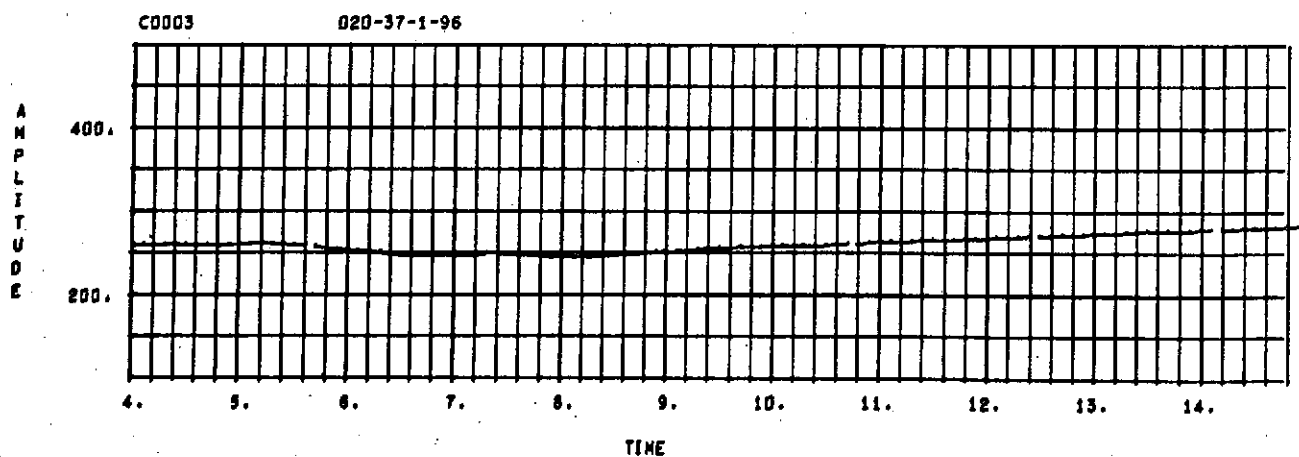
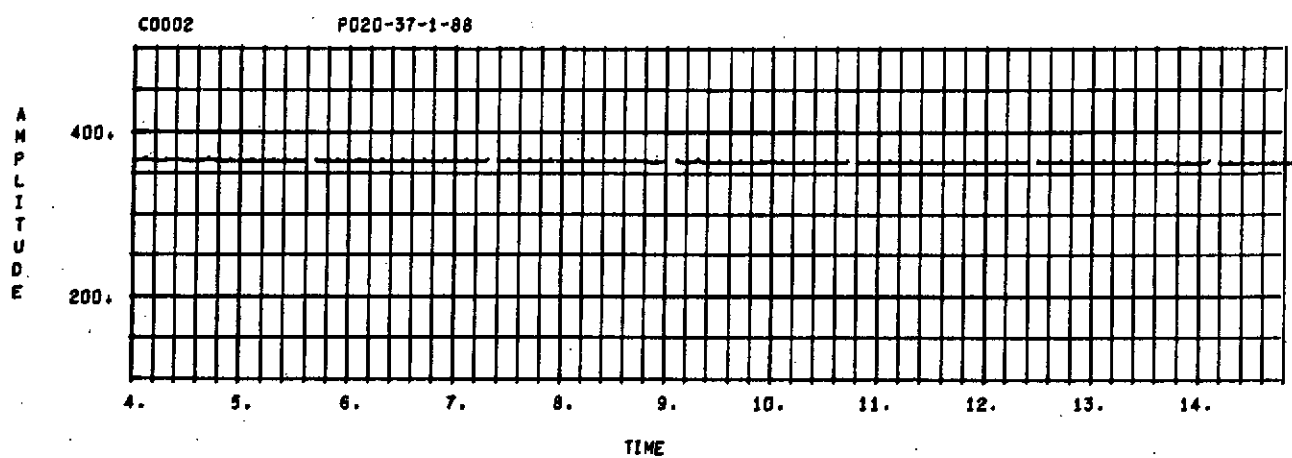
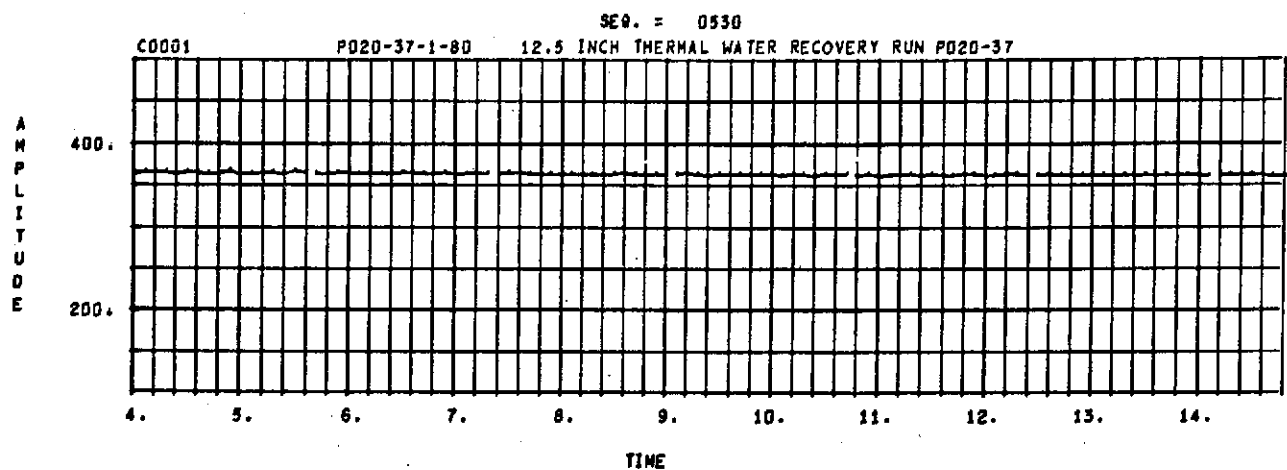
C0003 P020-37-1-96

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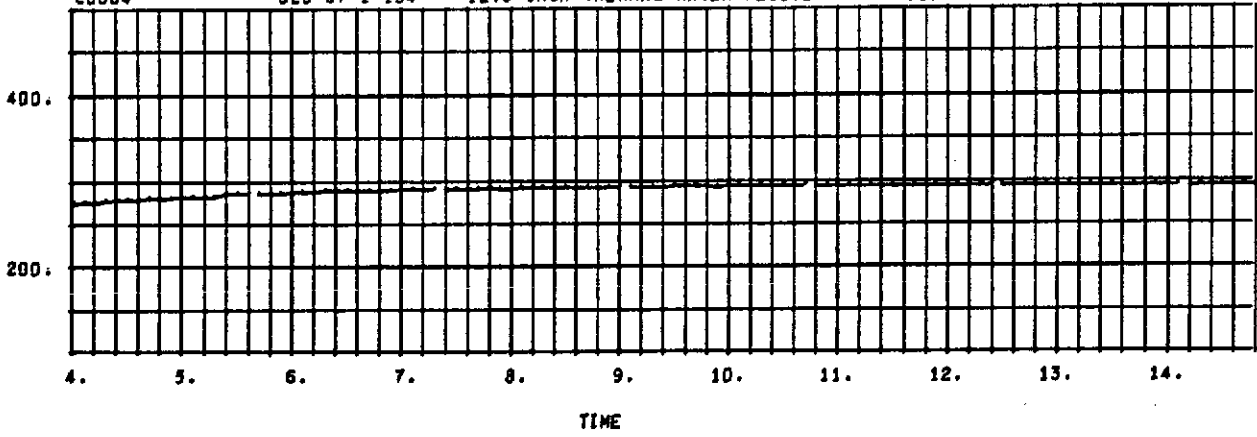




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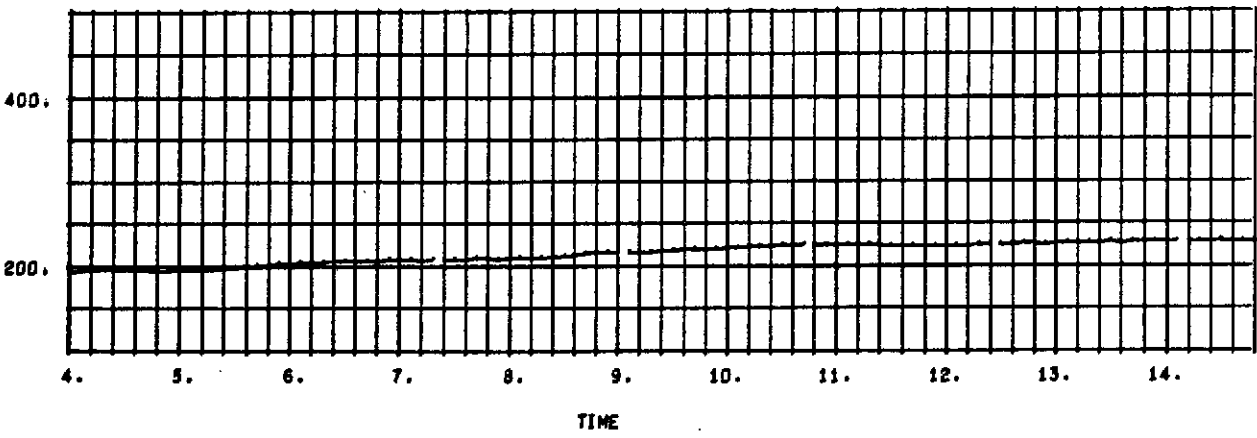
C0004 020-37-1-104 12.5 INCH THERMAL WATER RECOVERY RUN P020-37

AMPLITUDE



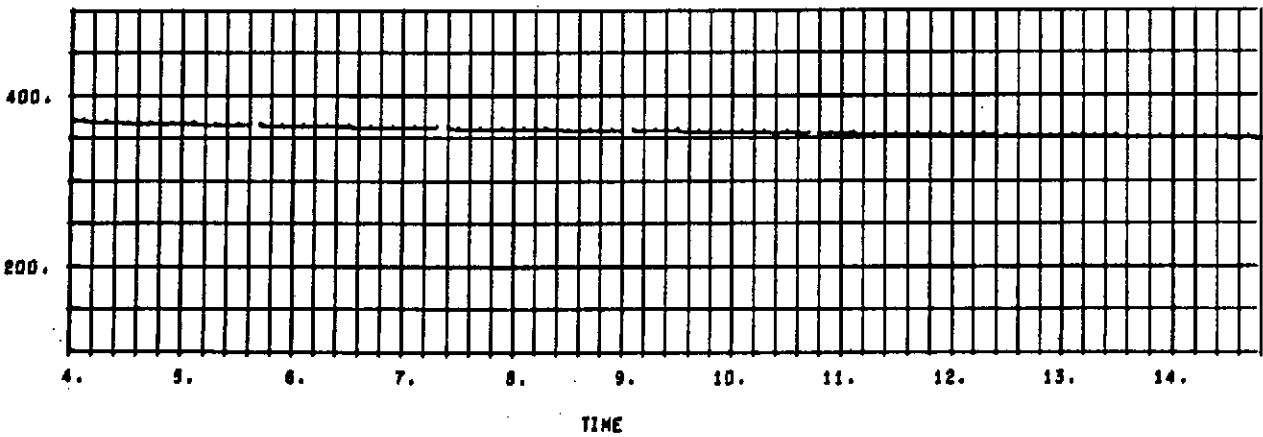
C0005 020-37-1-112

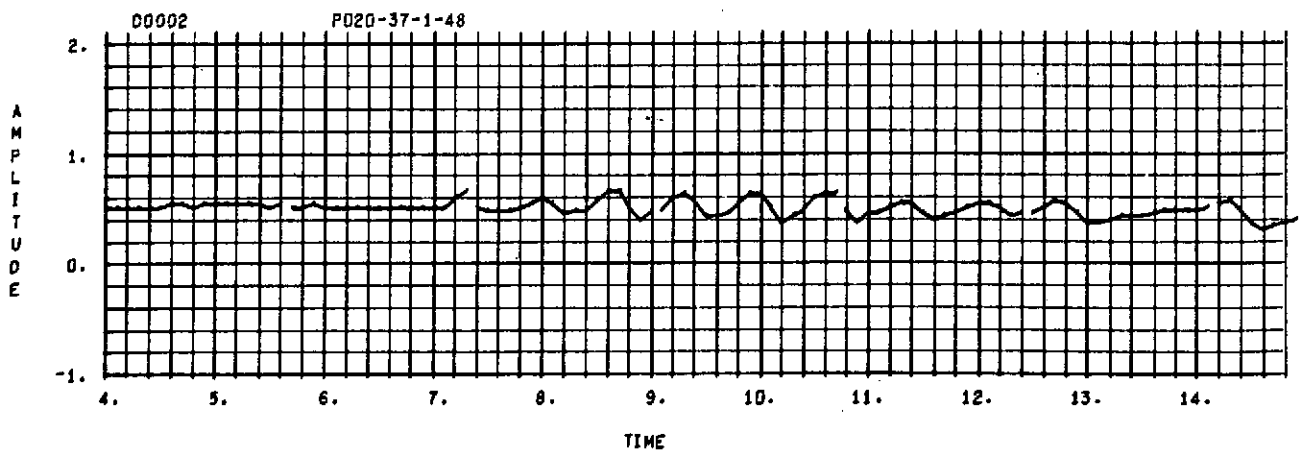
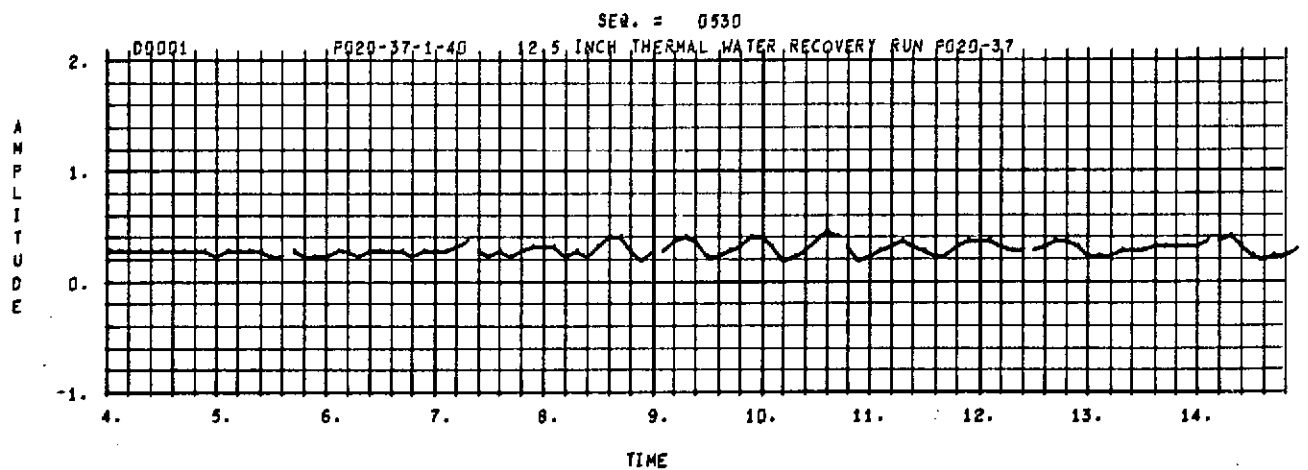
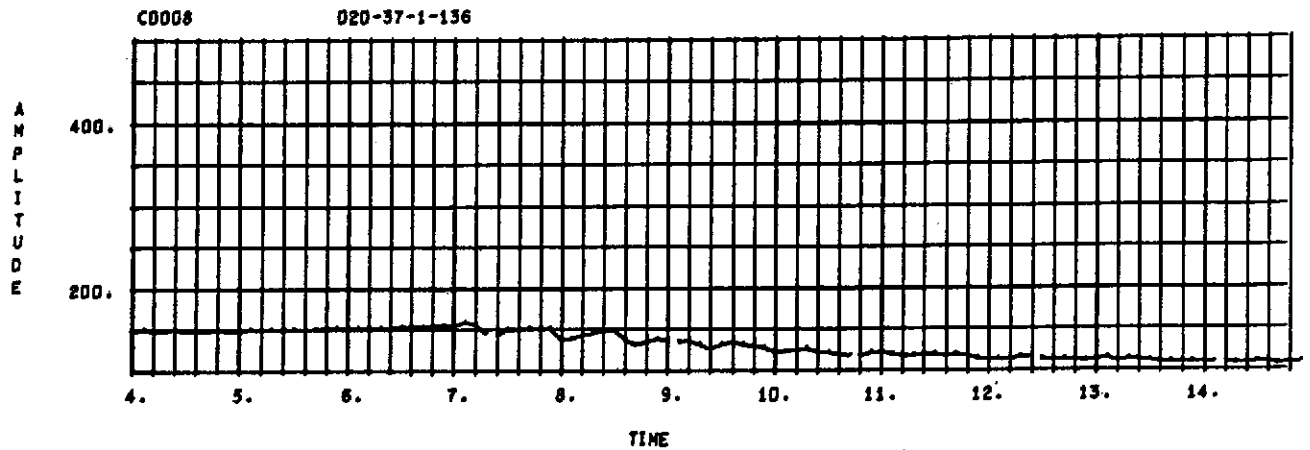
AMPLITUDE



C0006 020-37-1-120

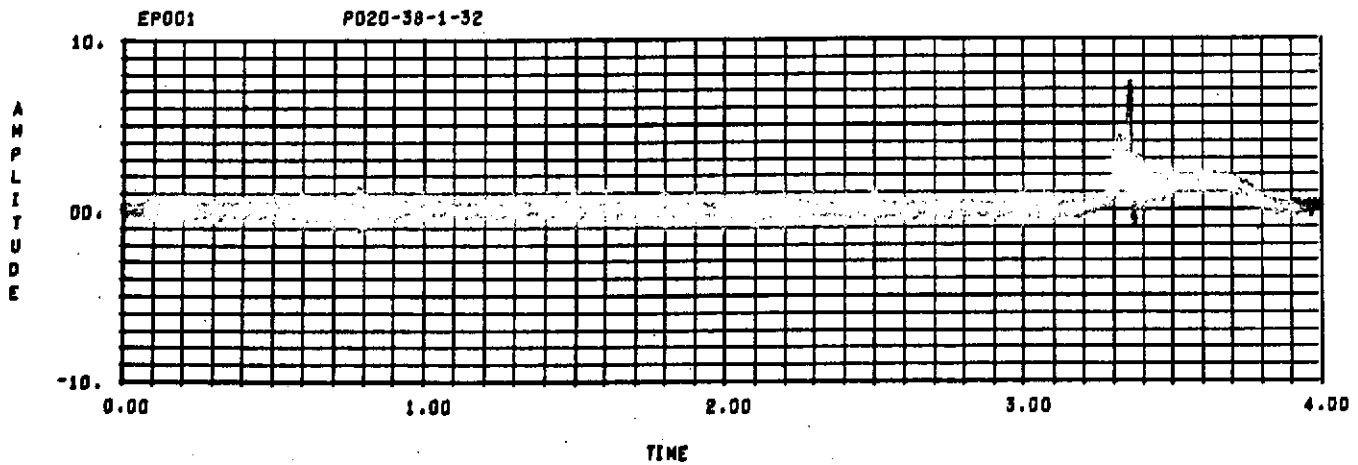
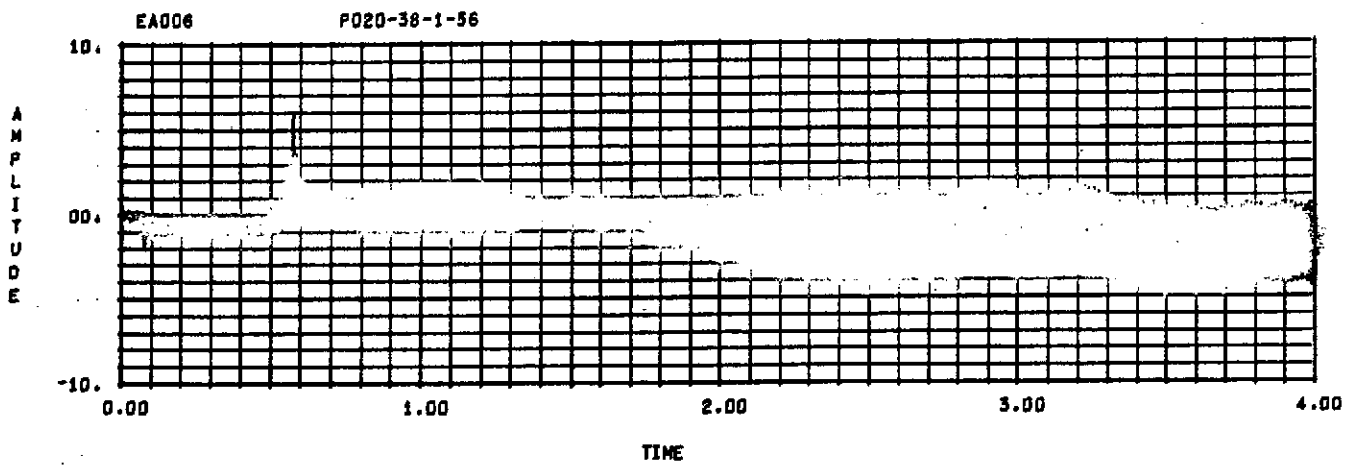
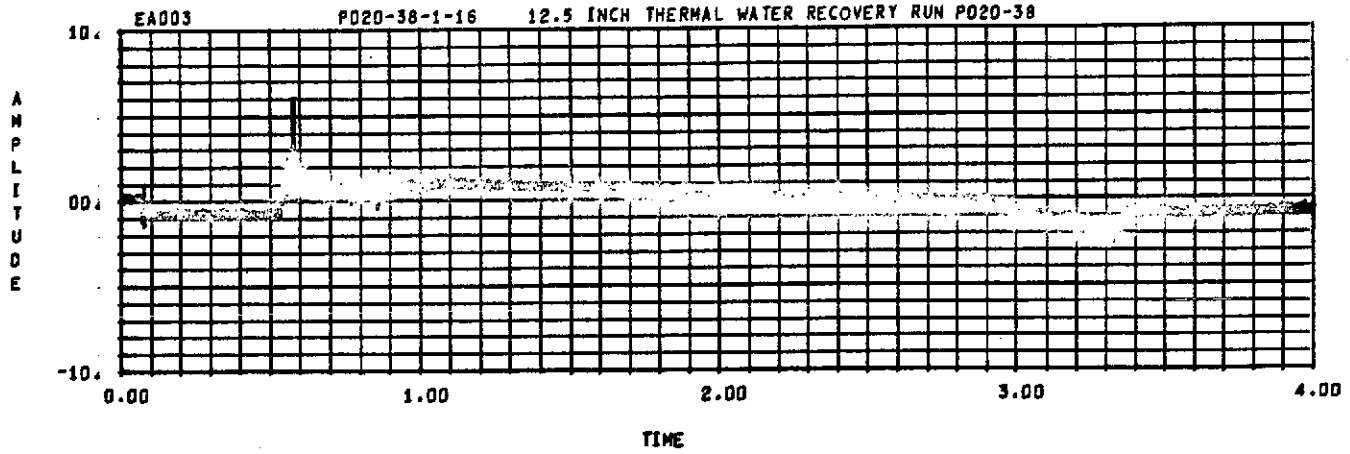
AMPLITUDE

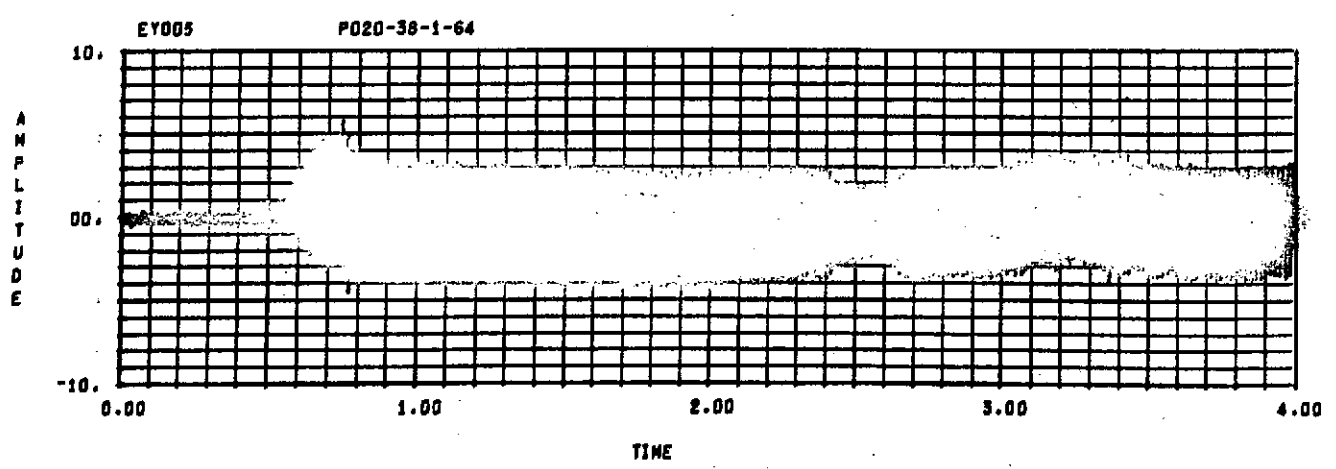
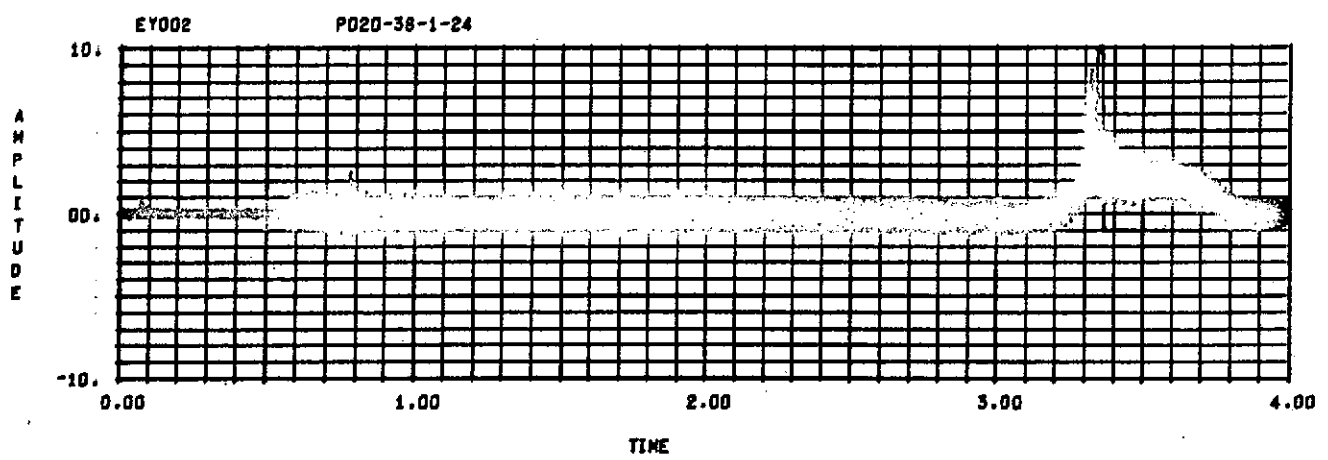
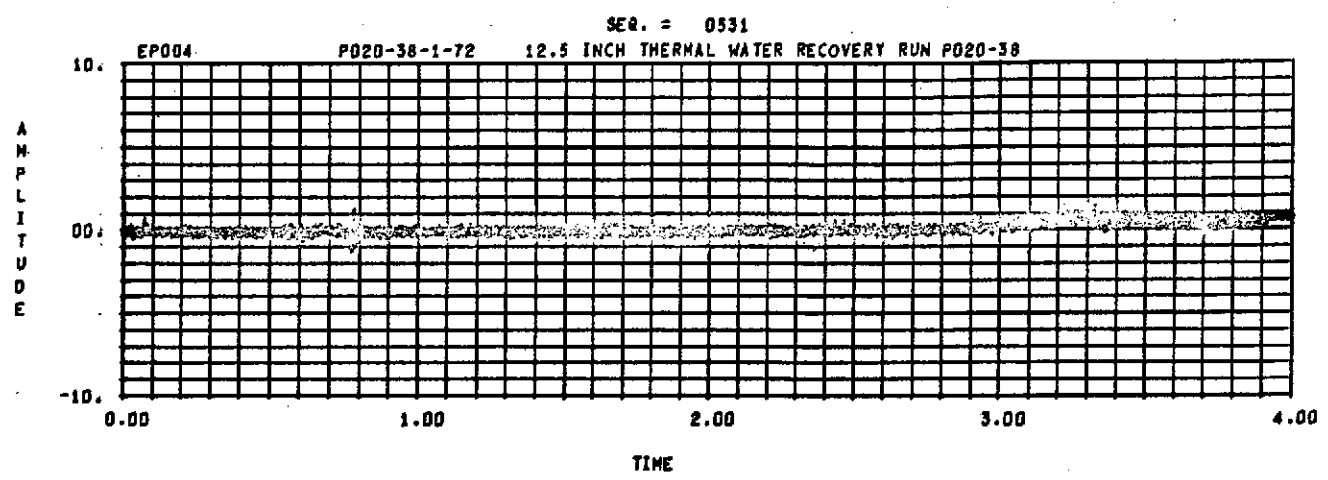


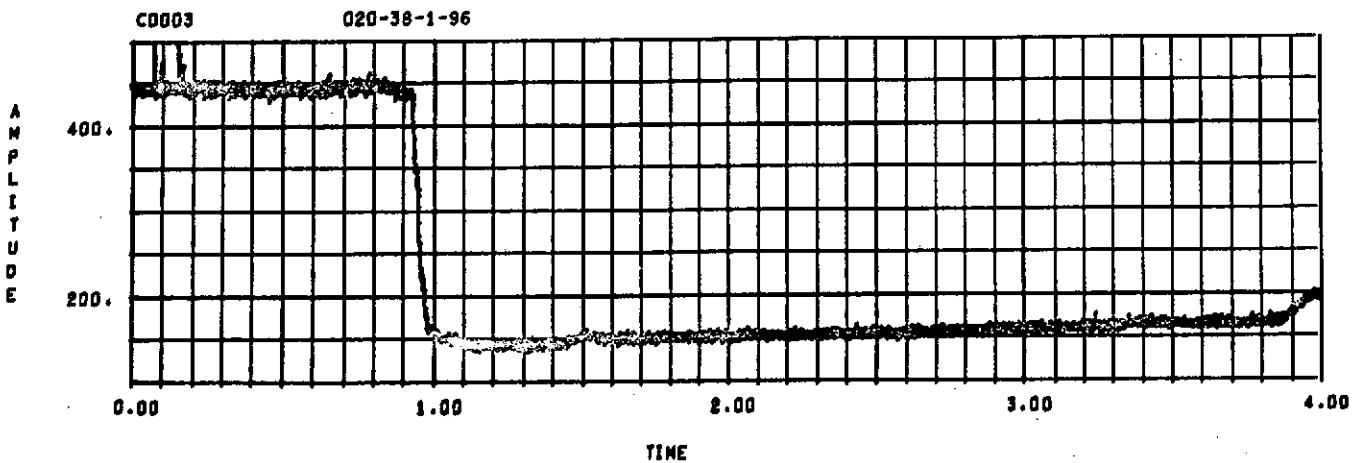
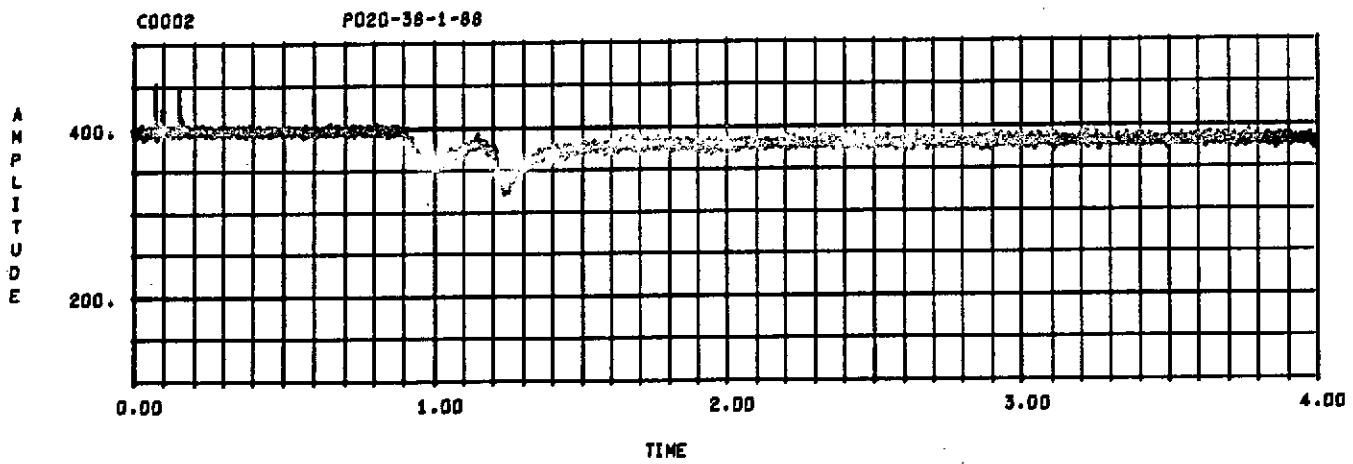
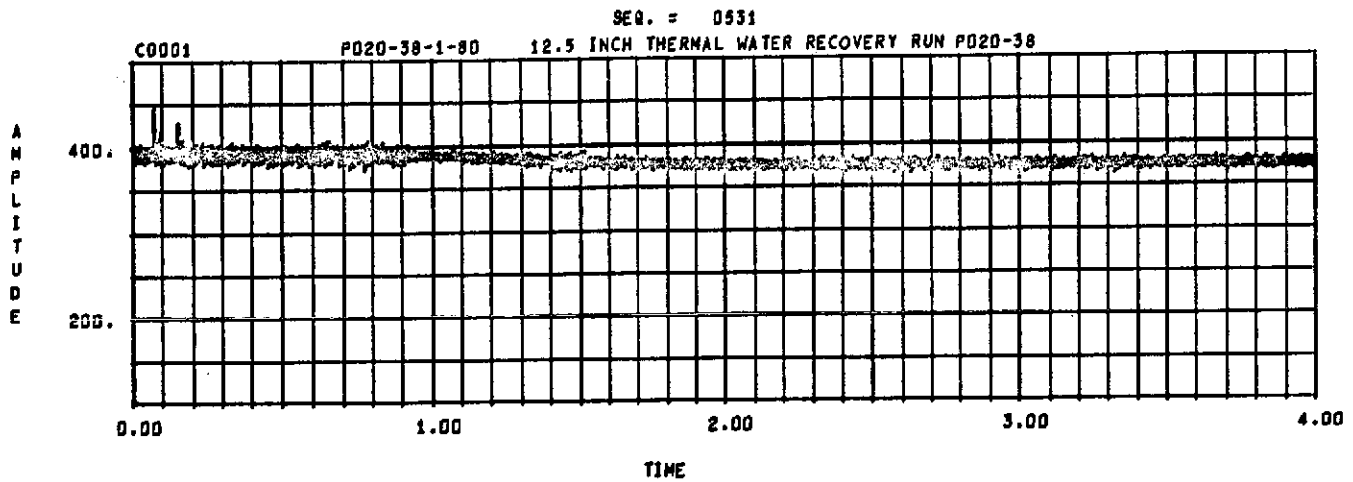


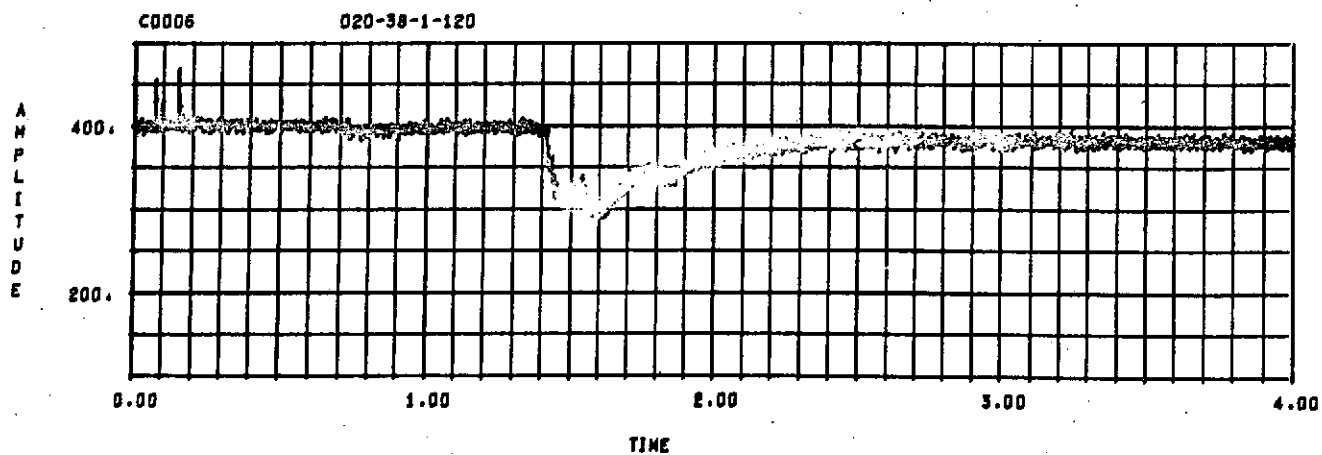
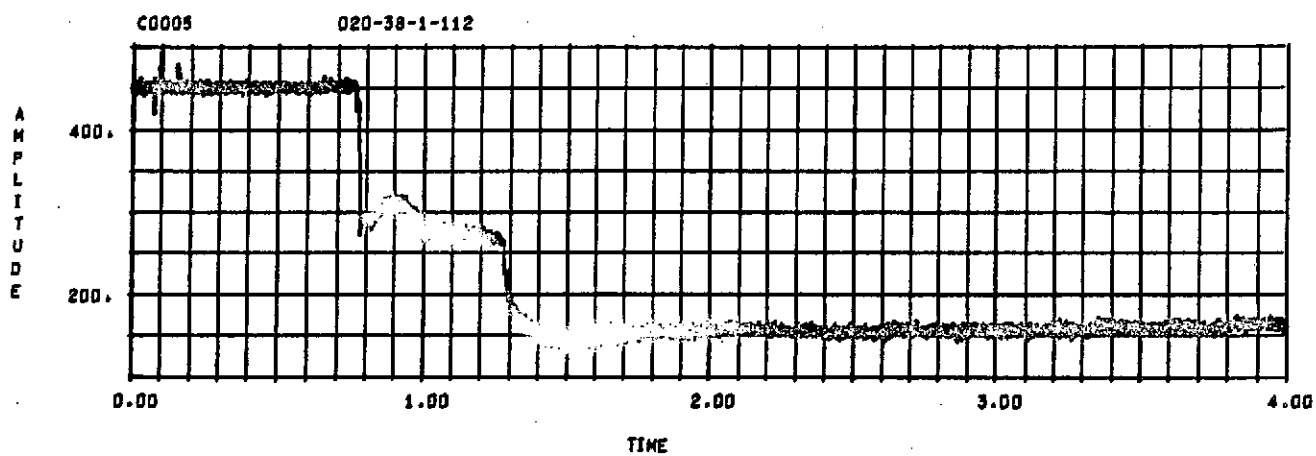
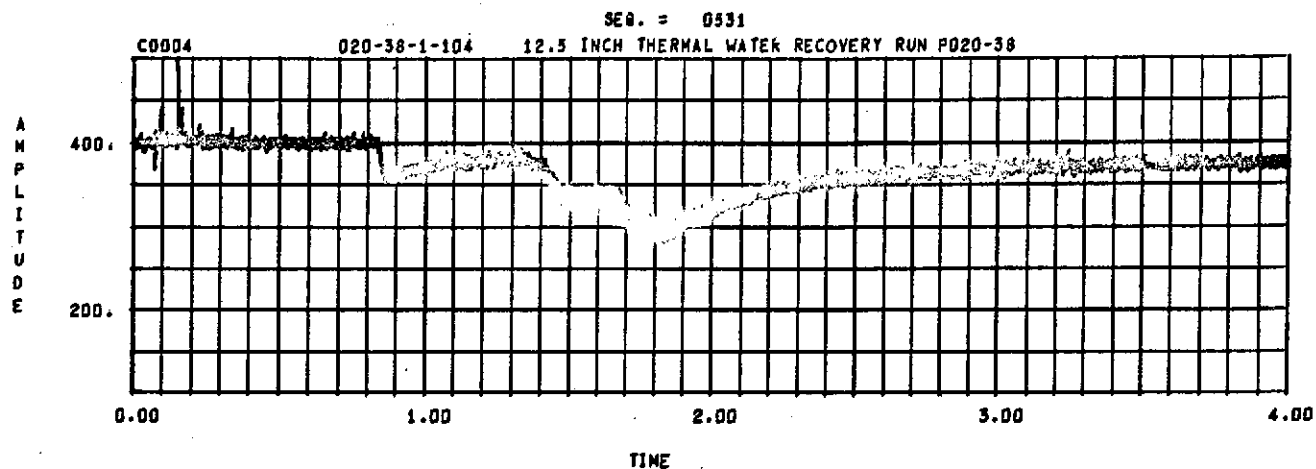
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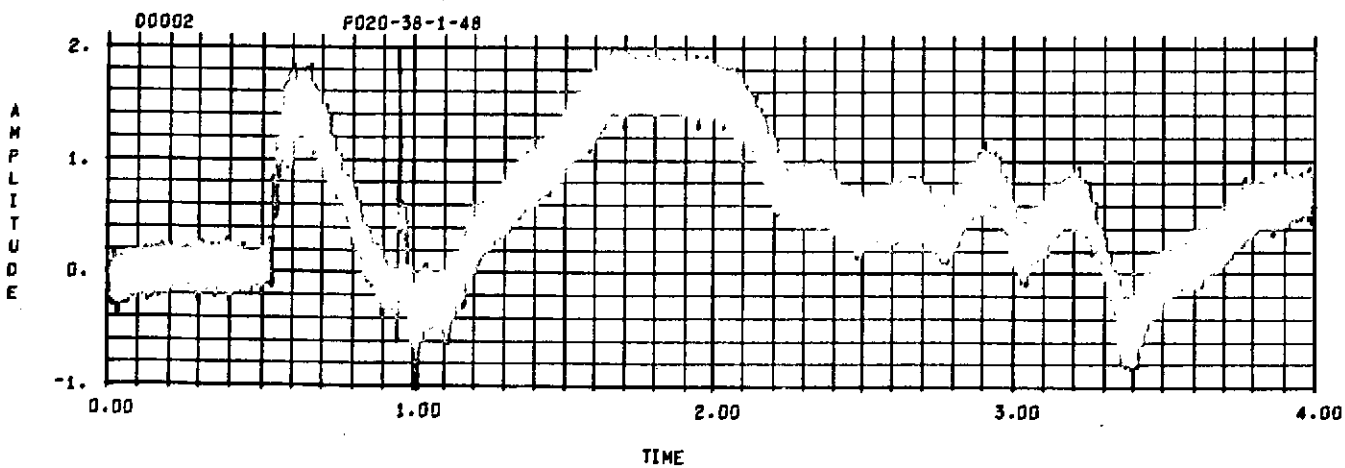
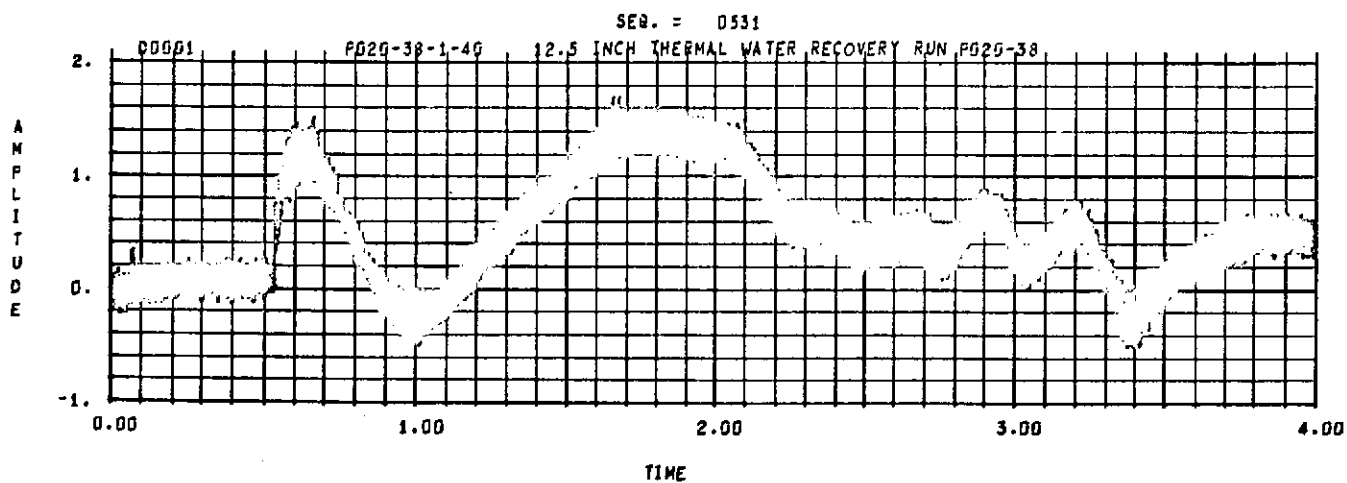
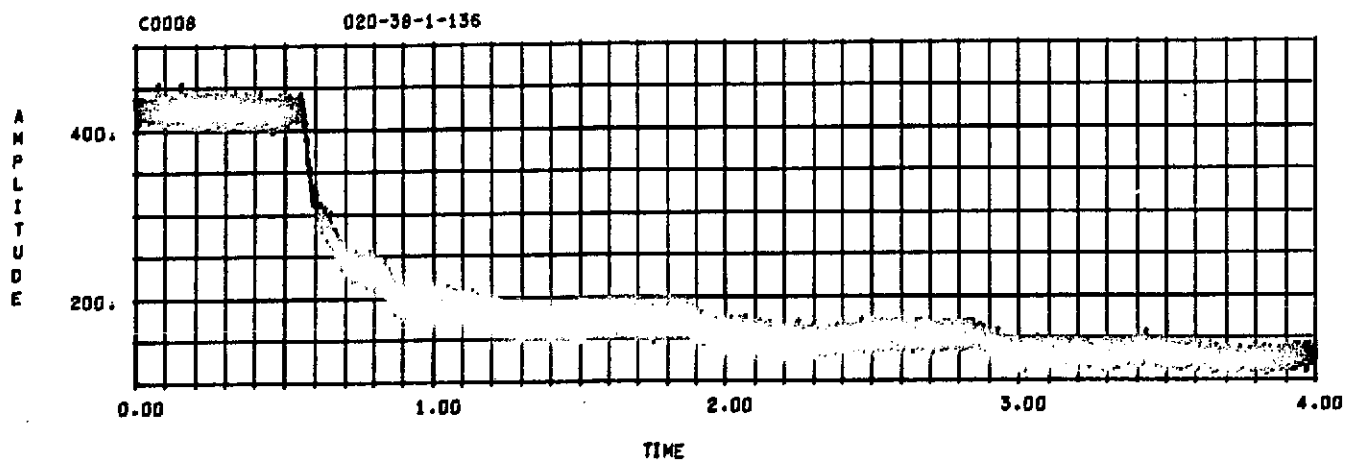
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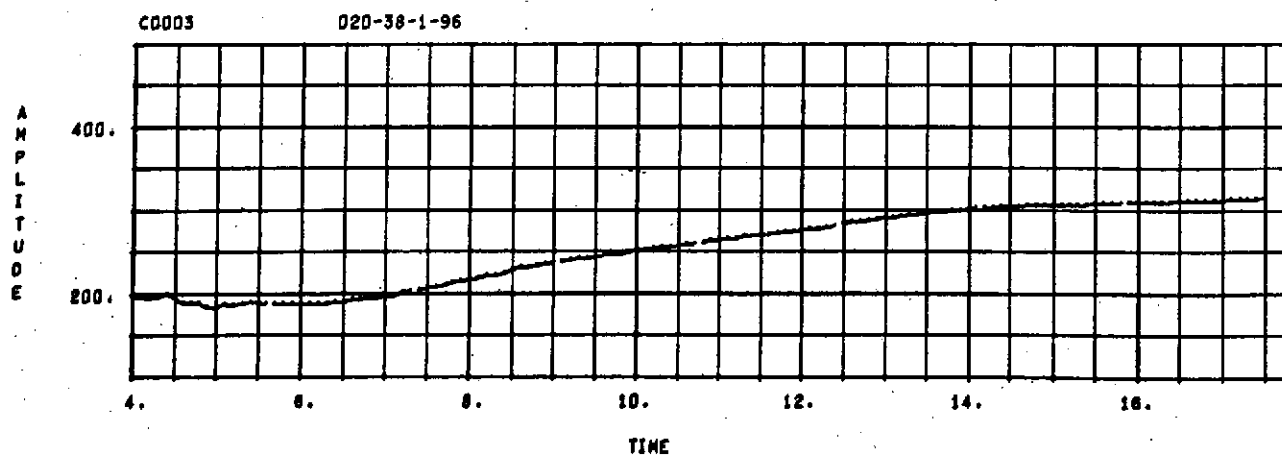
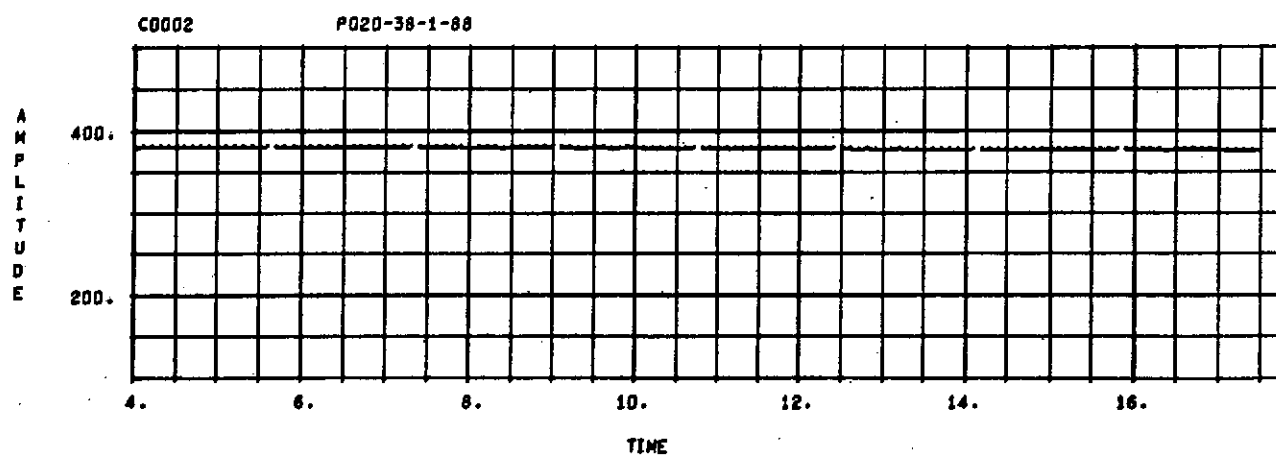
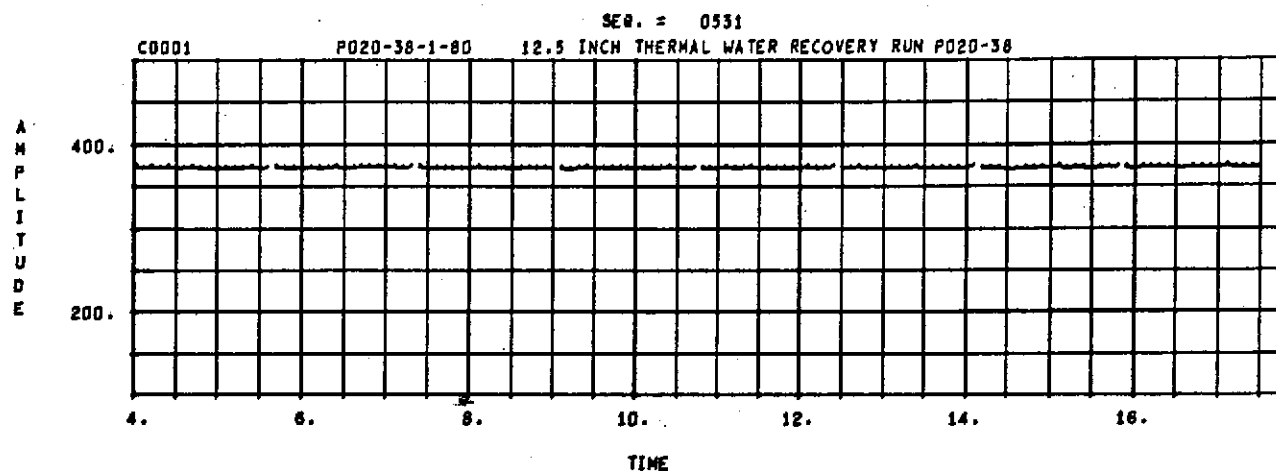










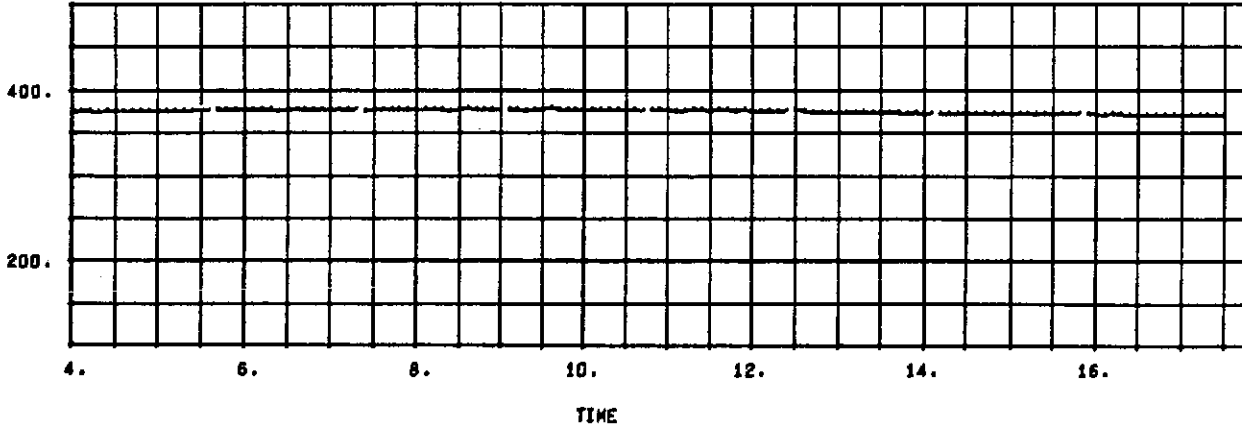


SEQ. = 0531

12

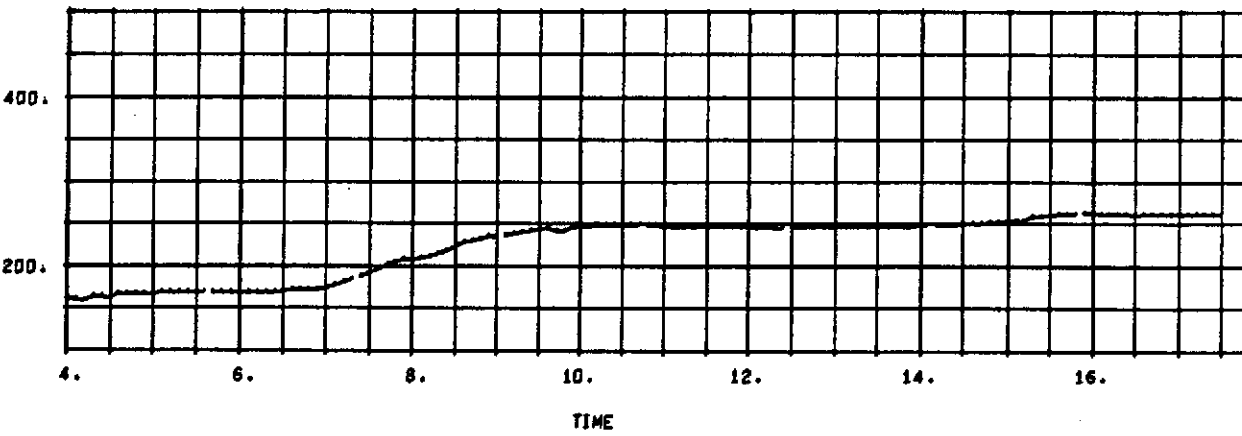
C0004 020-38-1-104 12.5 INCH THERMAL WATER RECOVERY RUN P020-38

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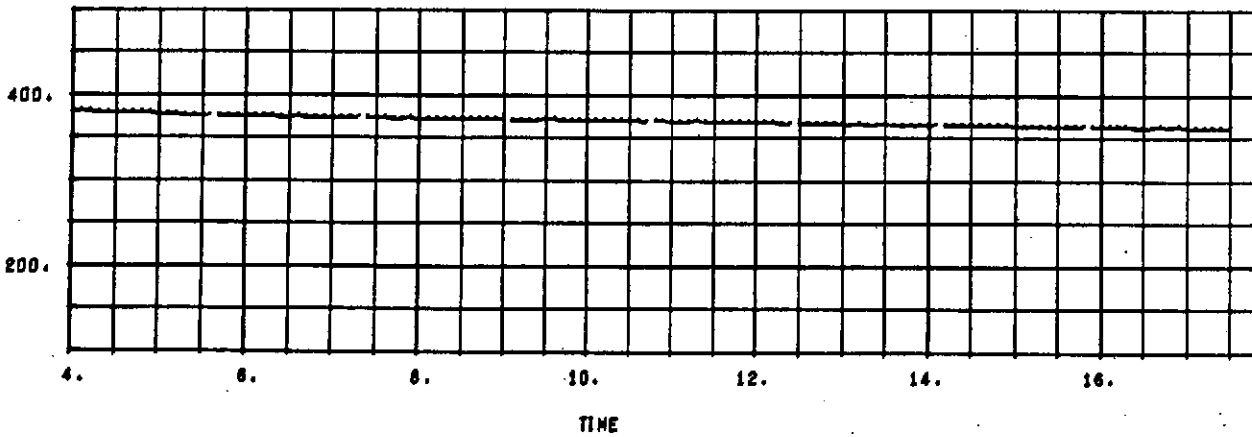
C0005 020-38-1-112

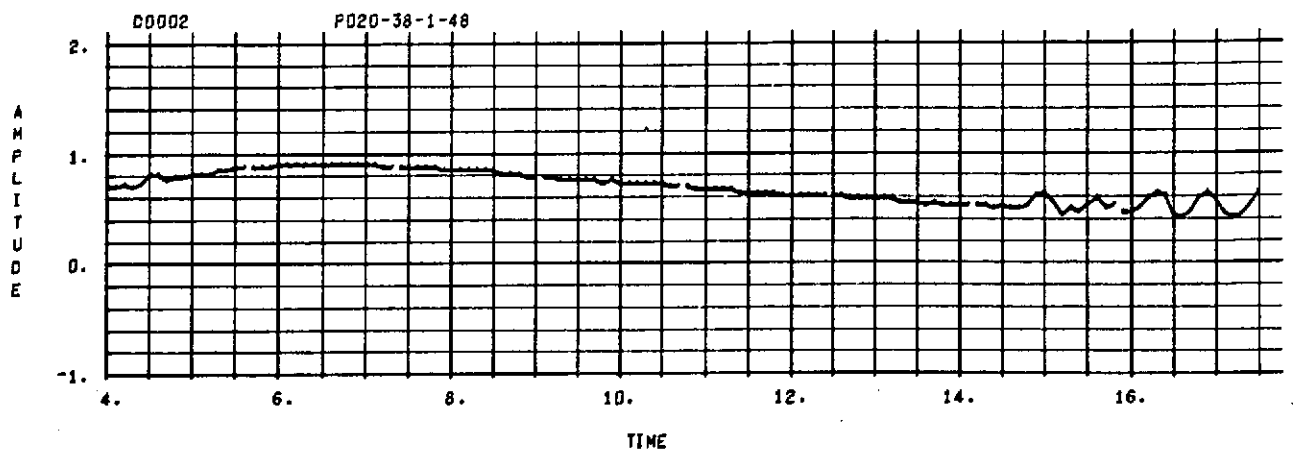
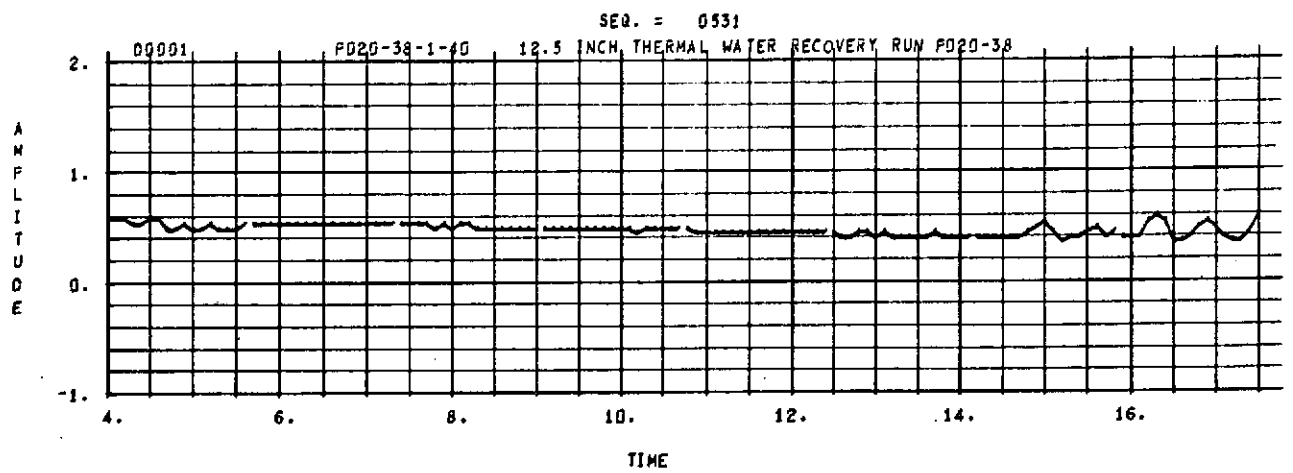
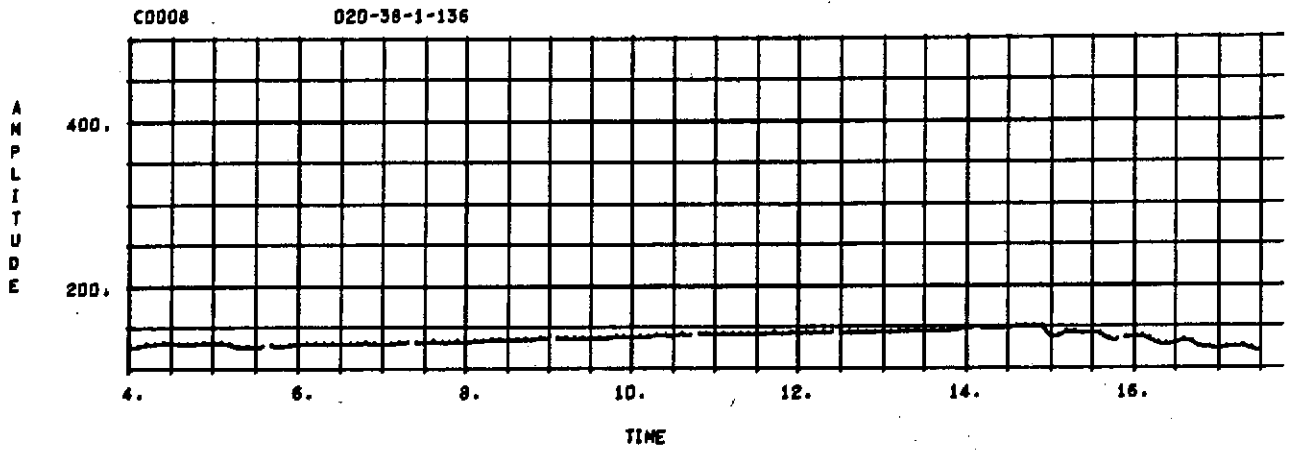
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C0006 020-38-1-120

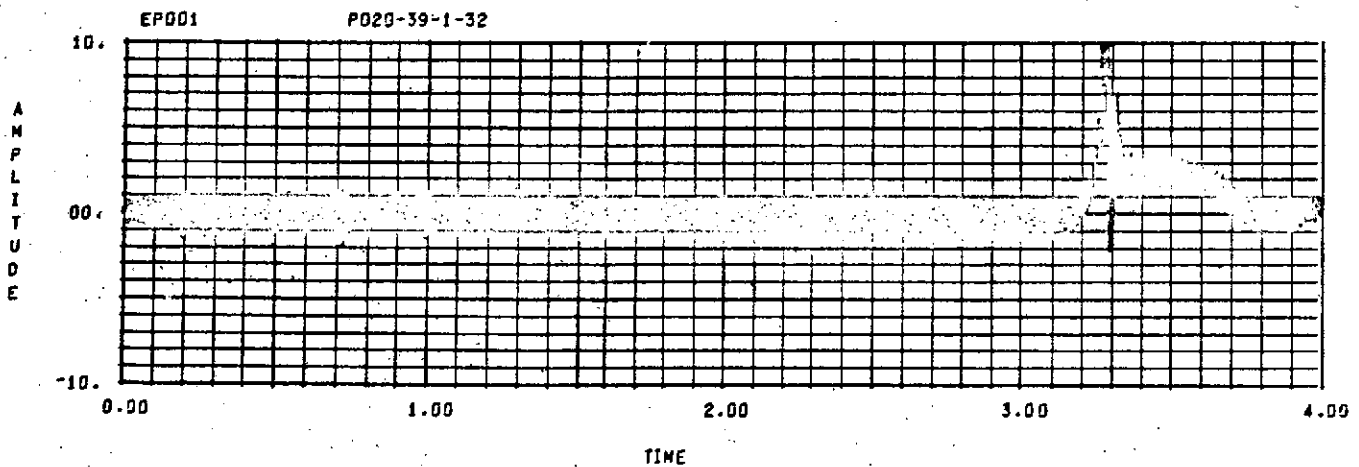
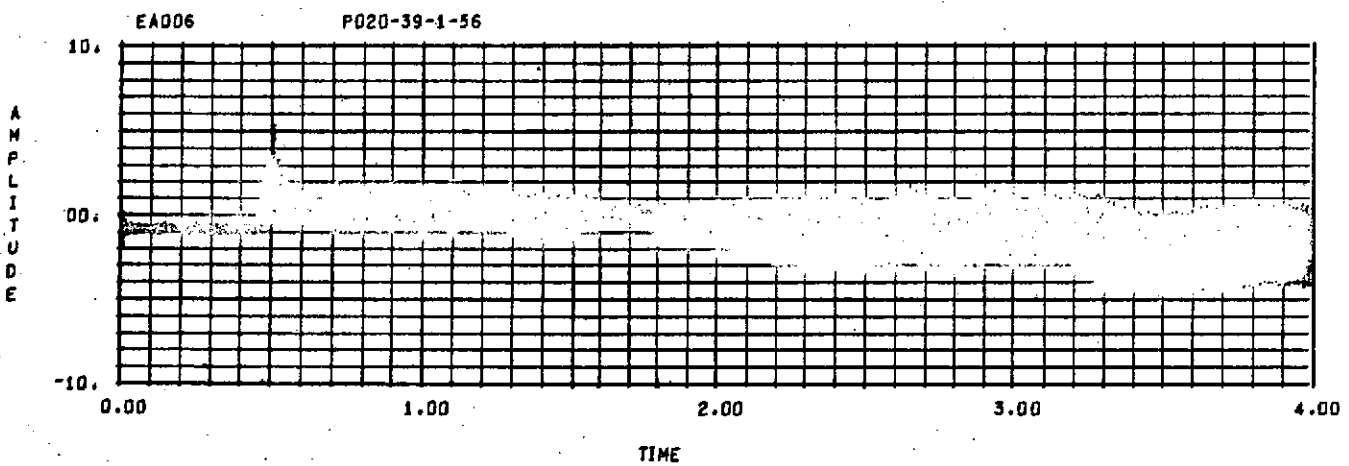
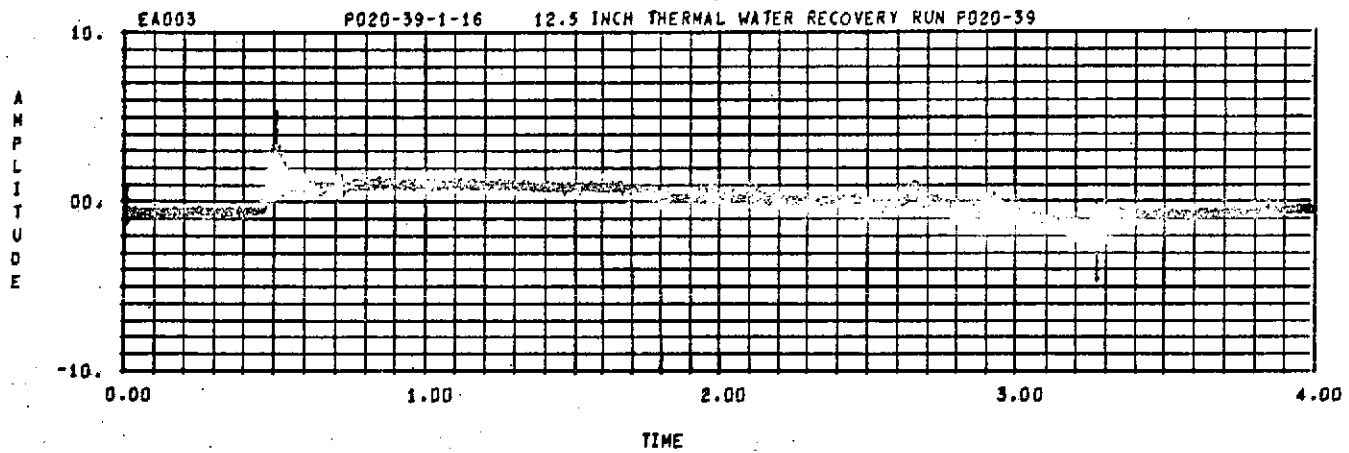
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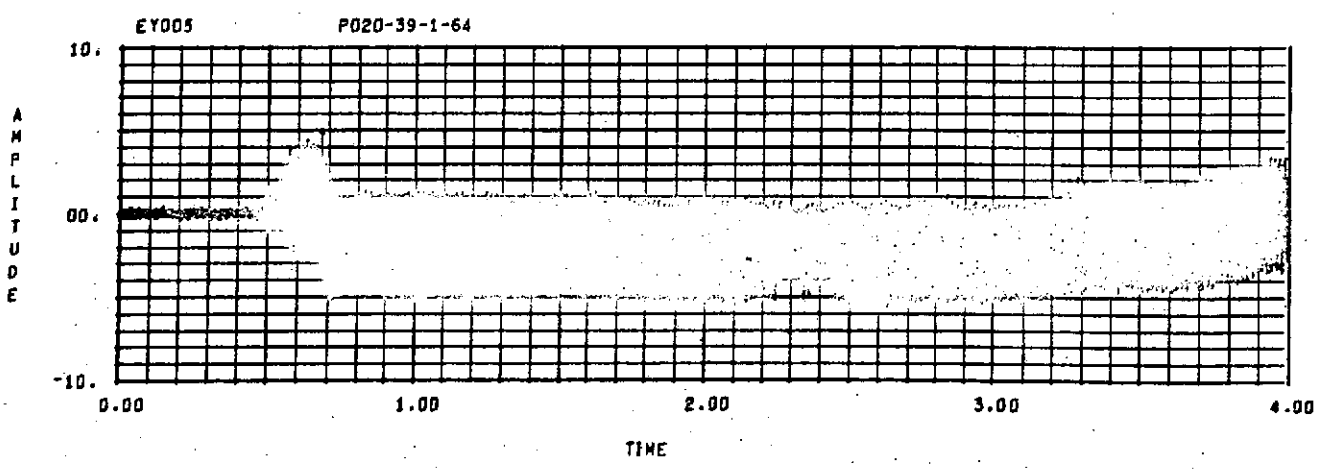
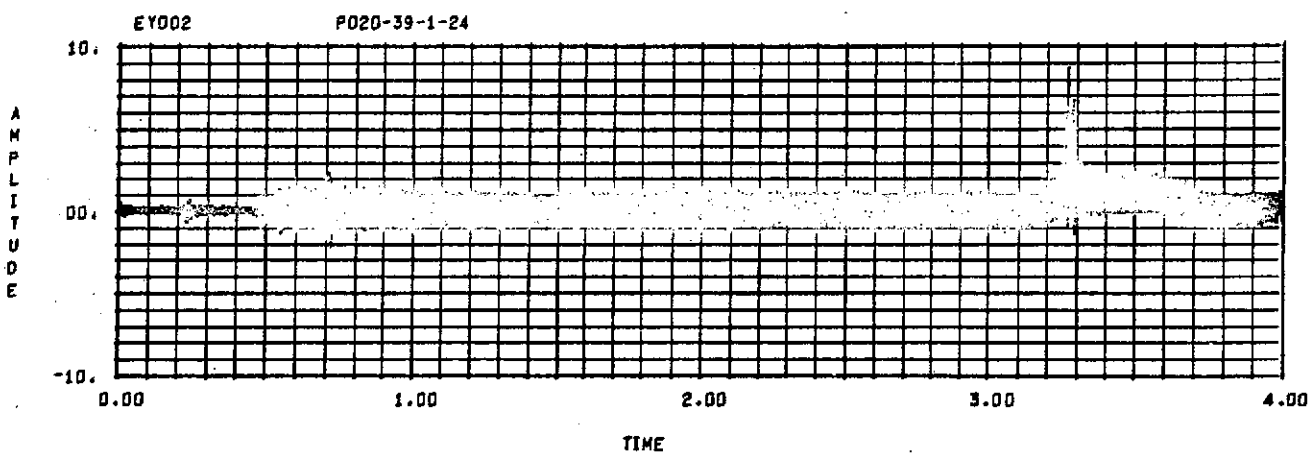
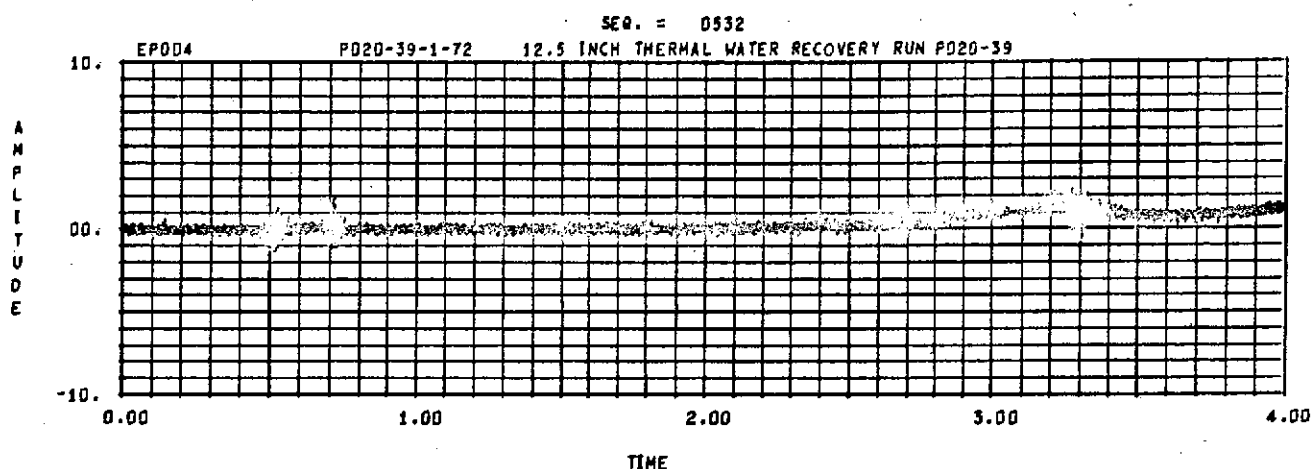




SEQ. = 0532

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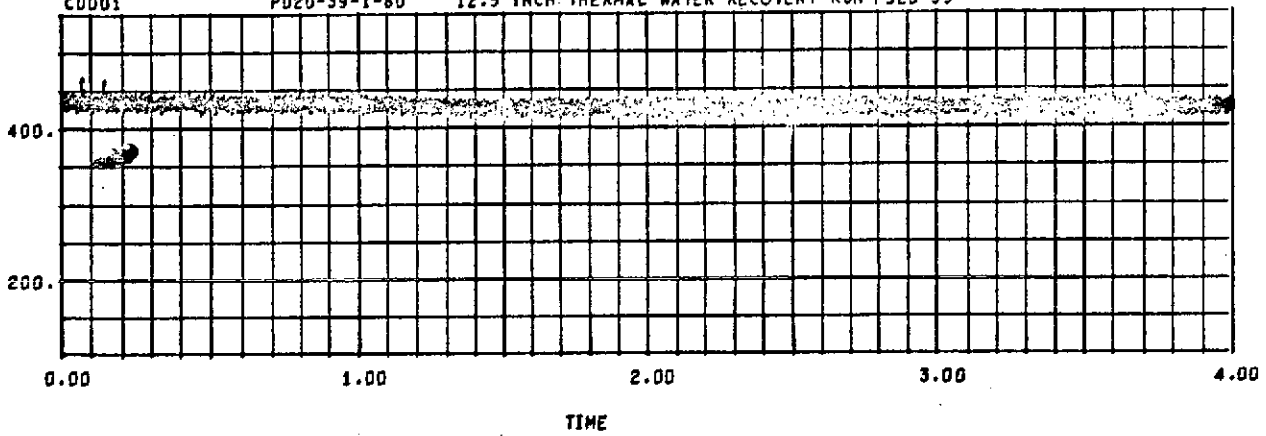


SEQ. = 0532

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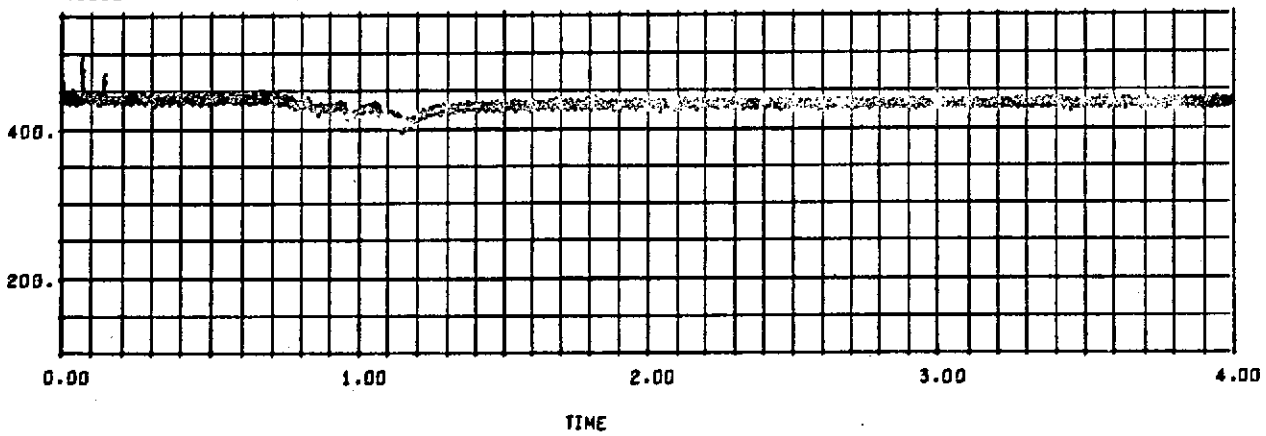
C0001 P020-39-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-39

AMPLITUDE



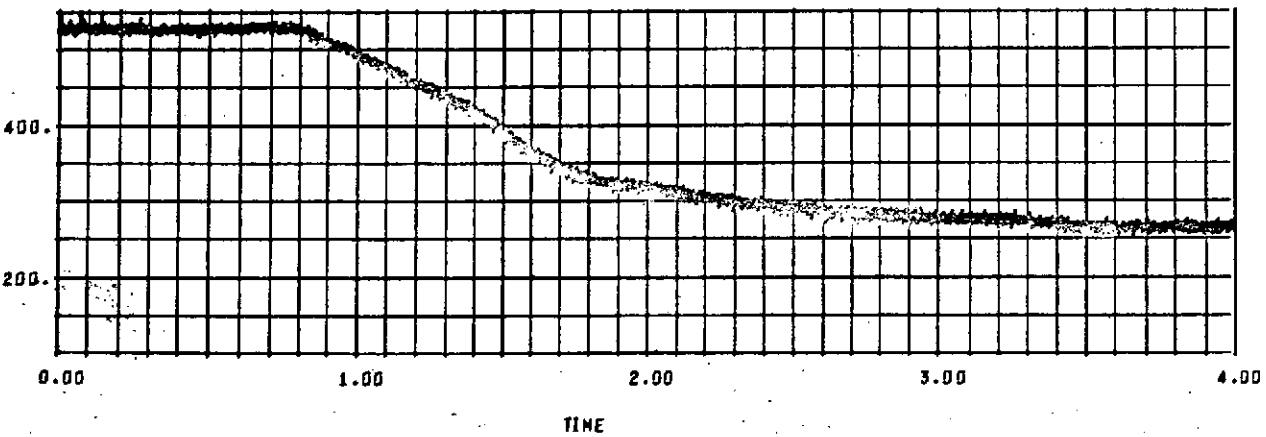
C0002 P020-39-1-88

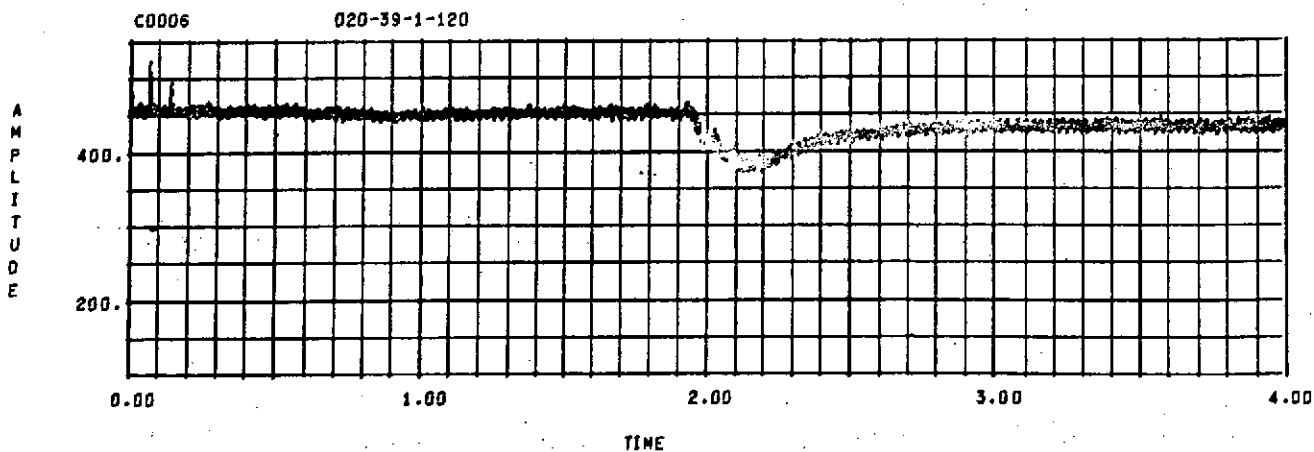
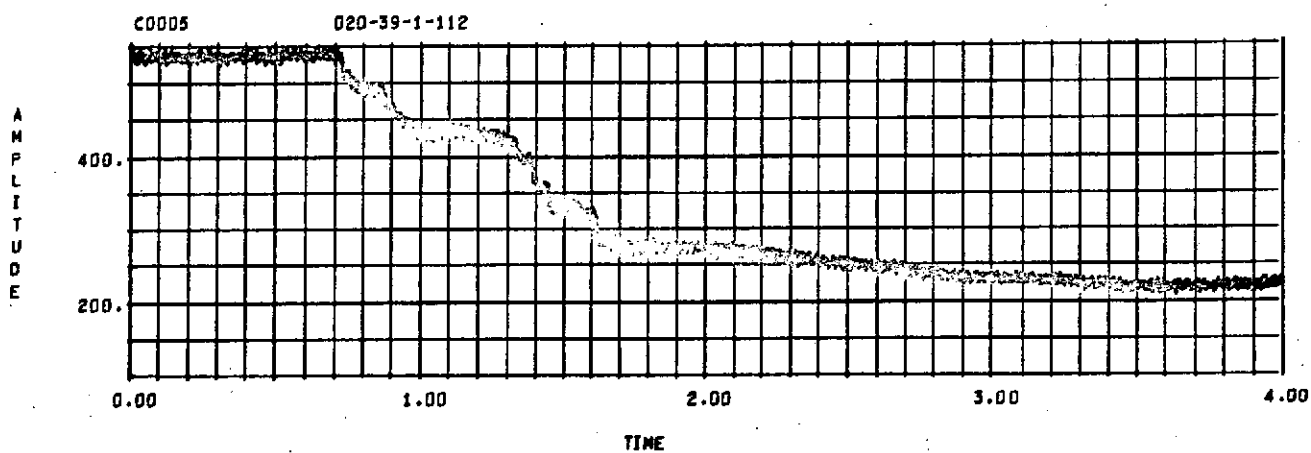
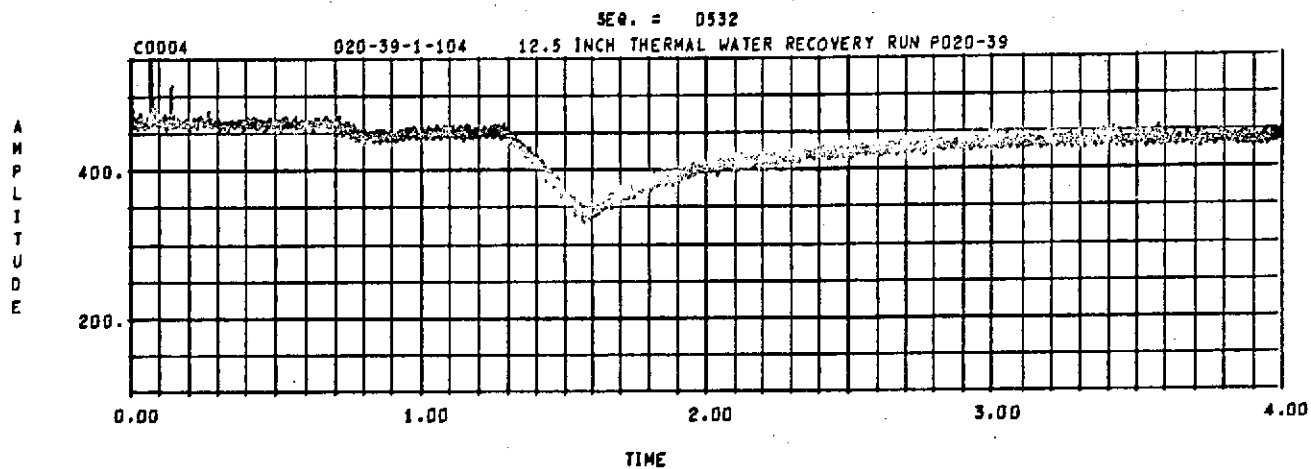
AMPLITUDE

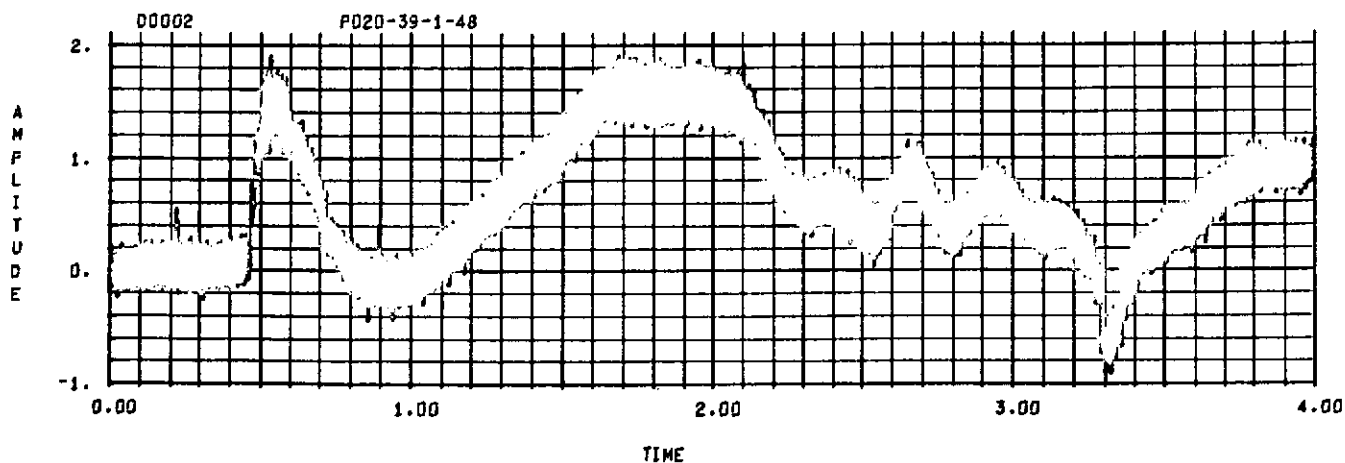
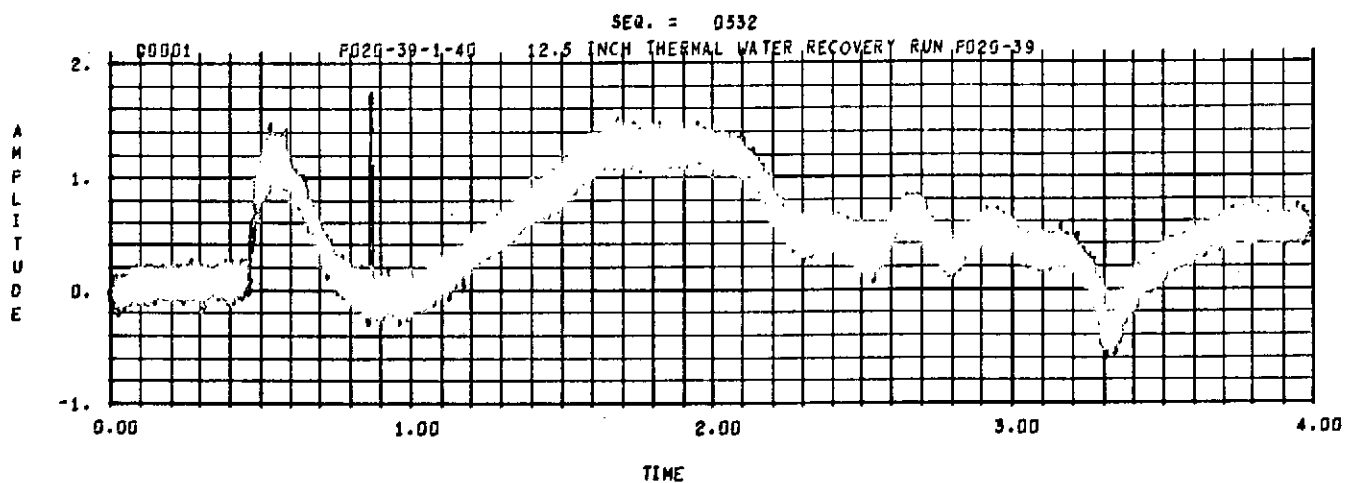
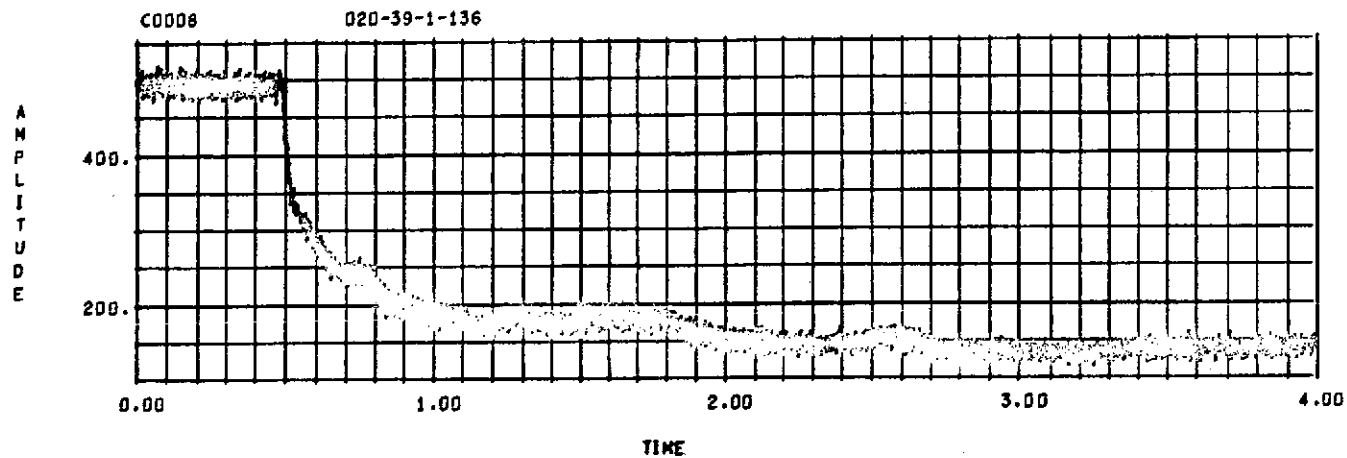


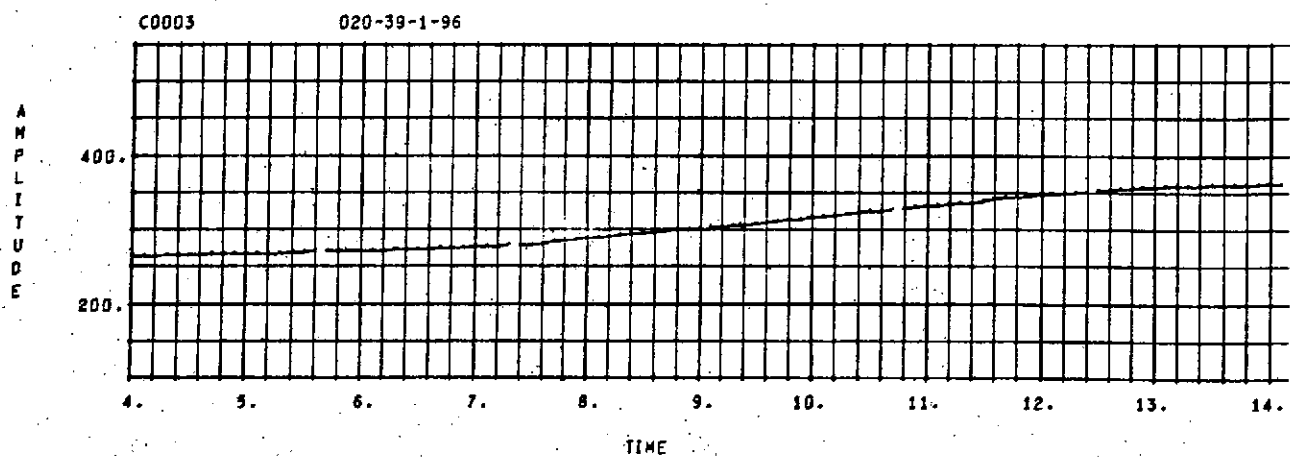
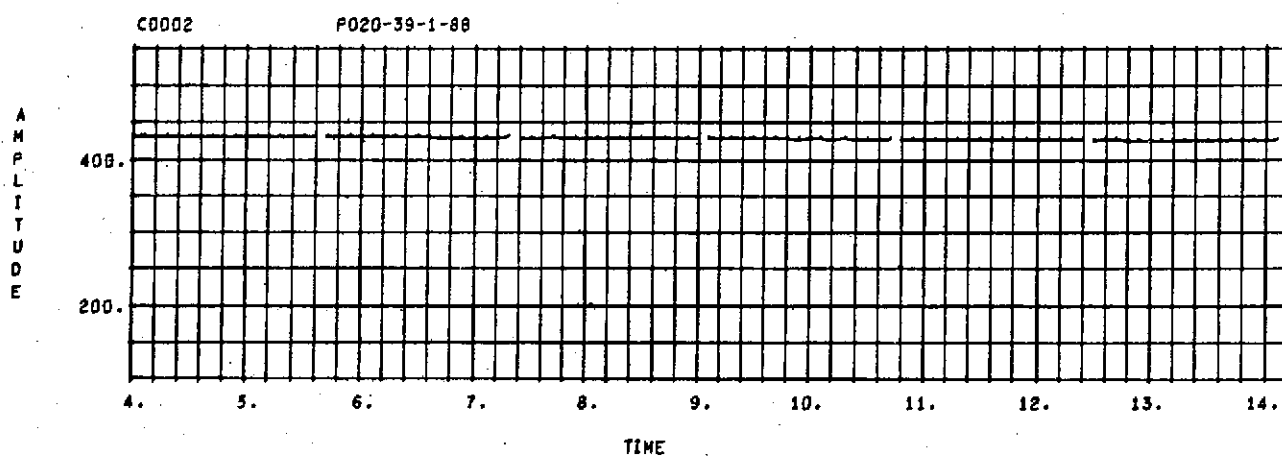
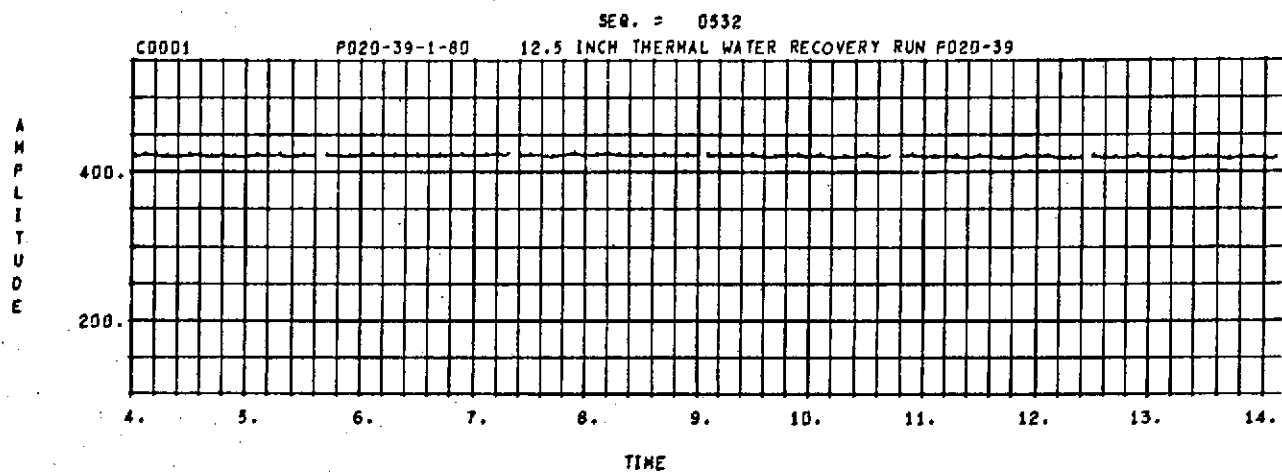
C0003 P020-39-1-96

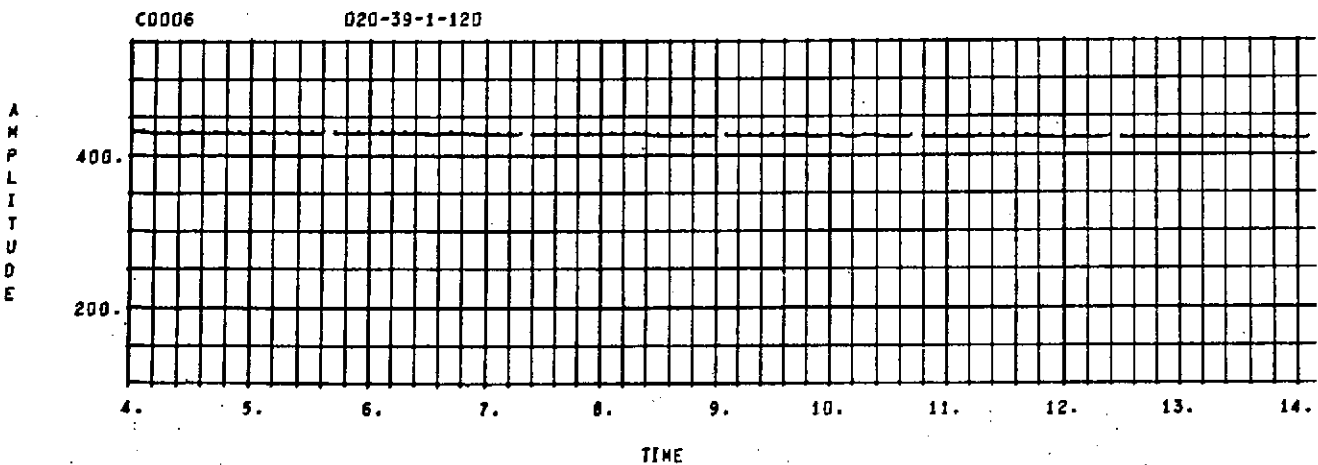
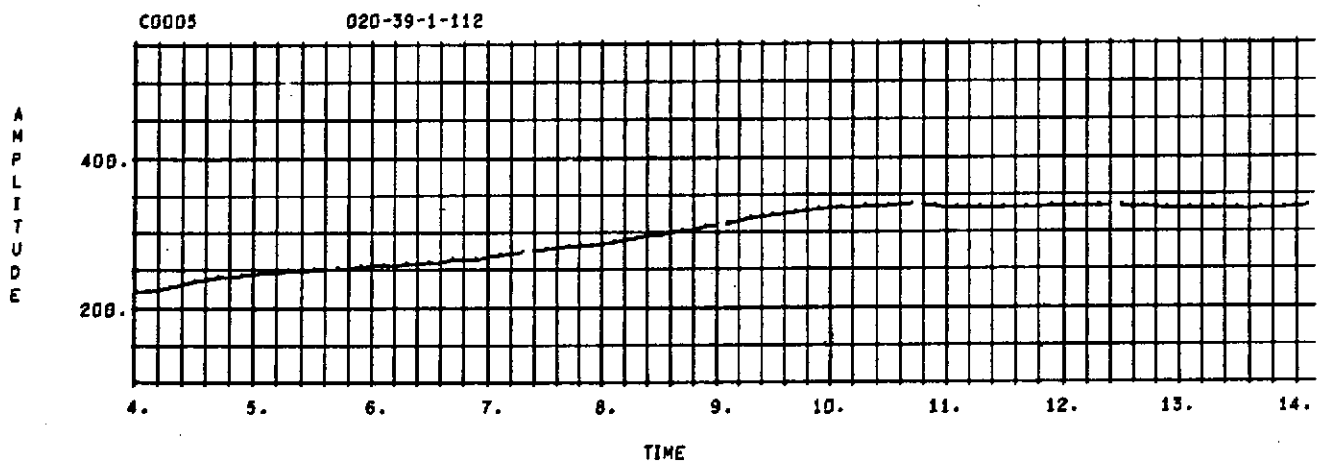
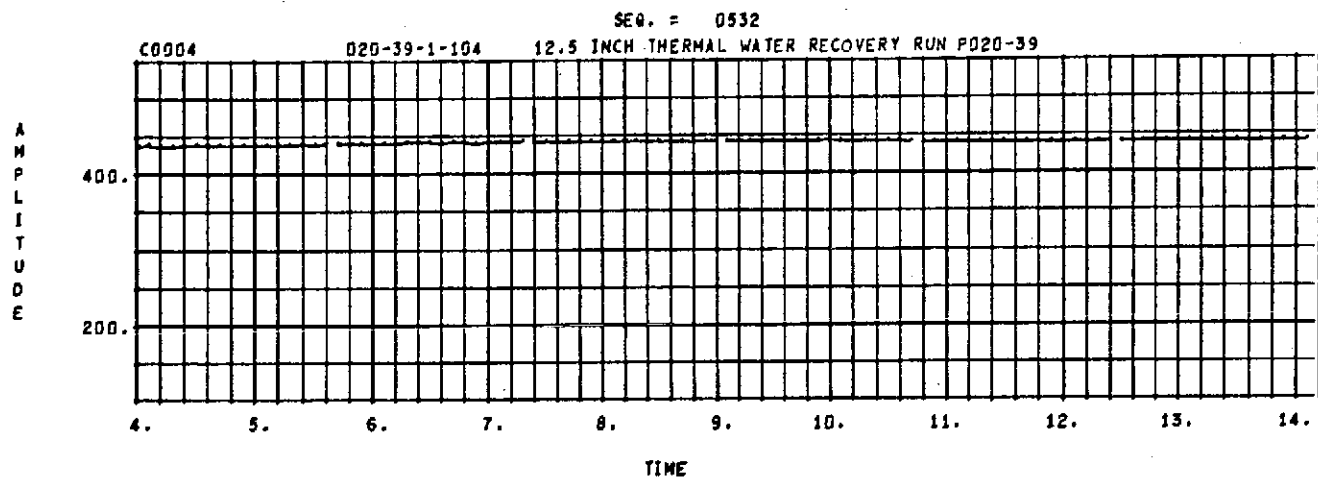
AMPLITUDE

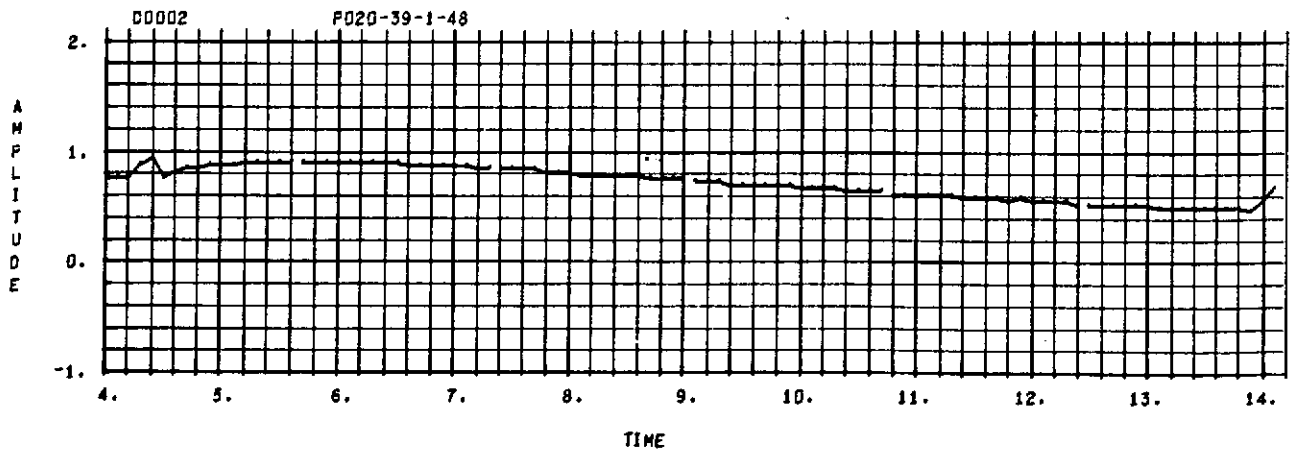
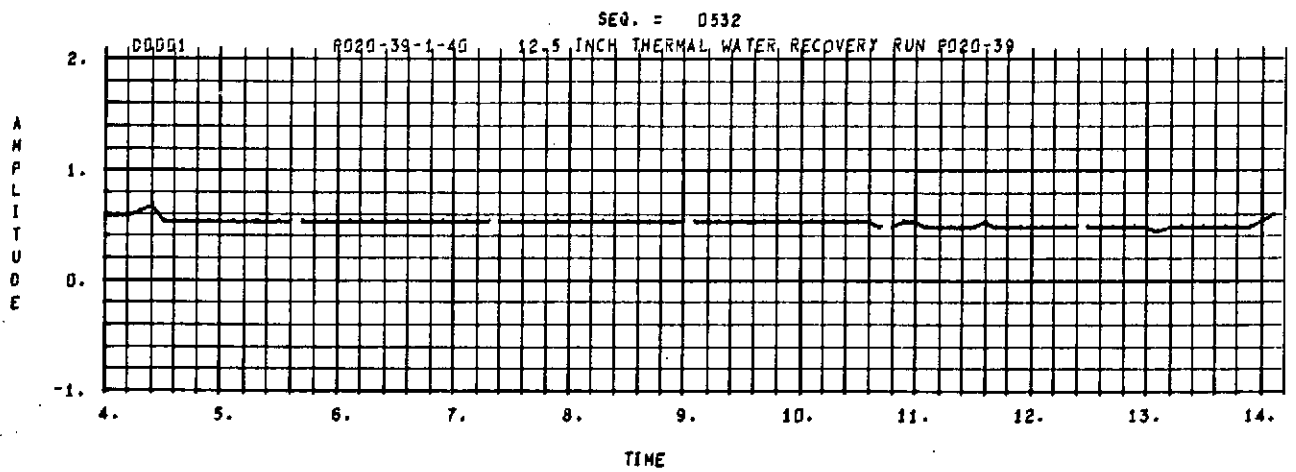
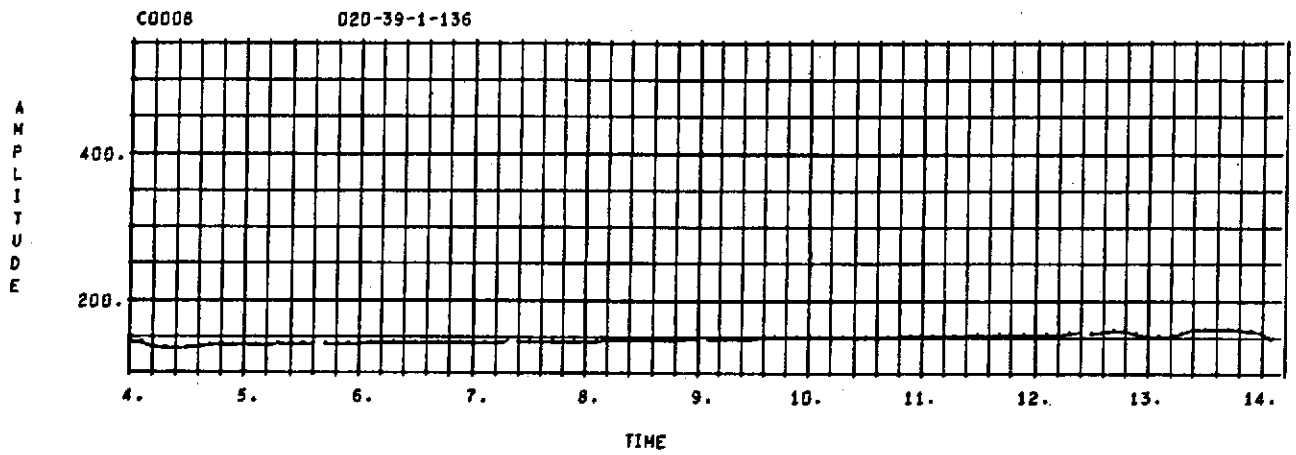






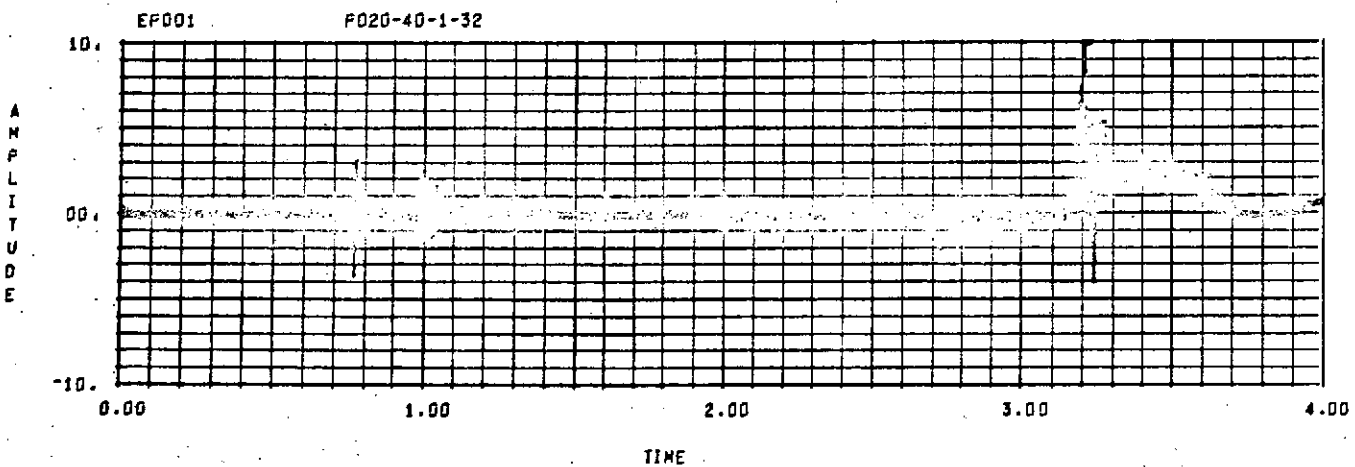
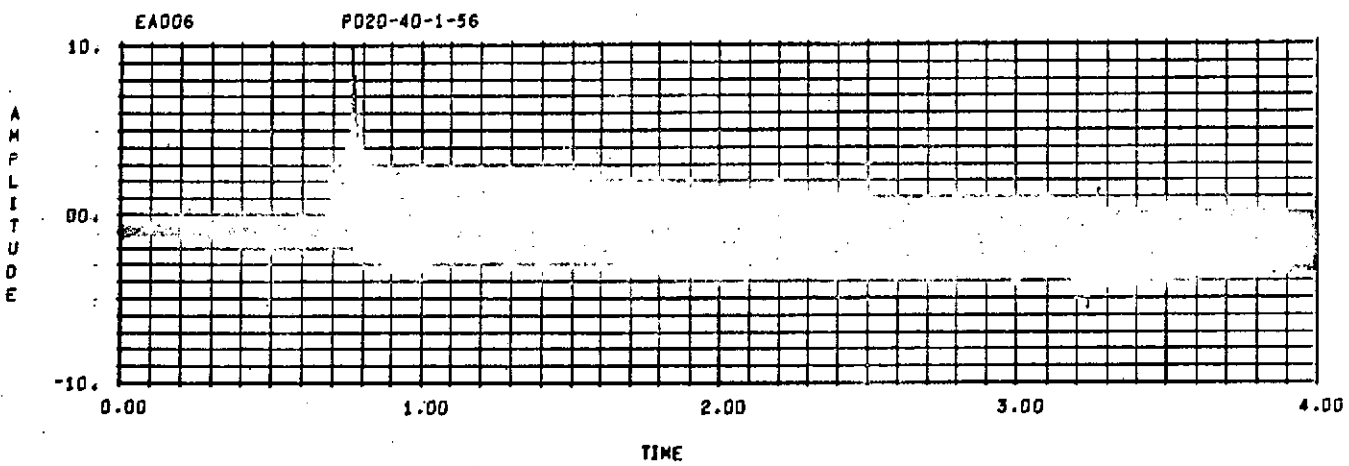
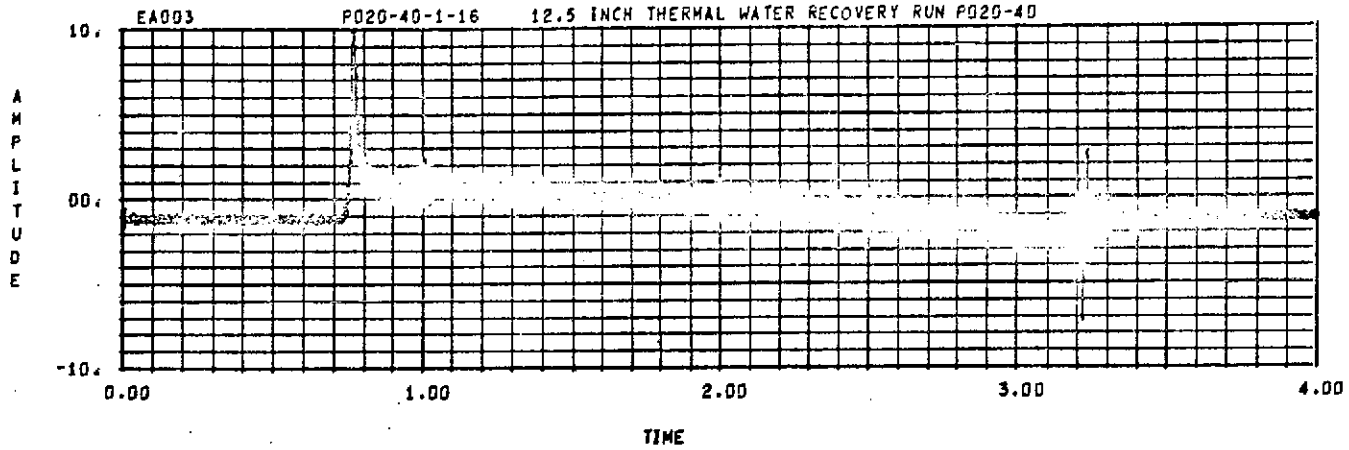


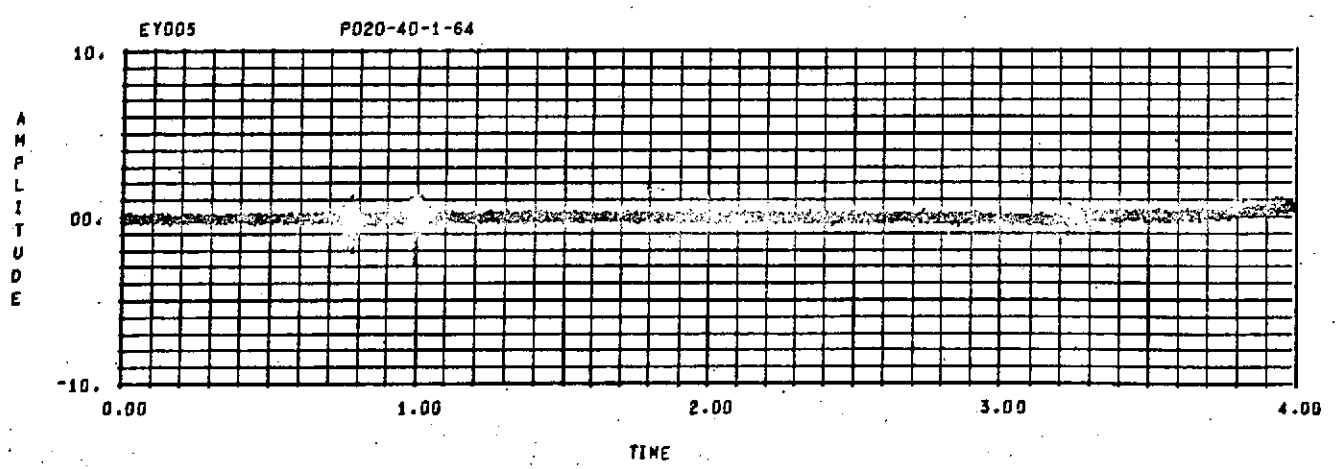
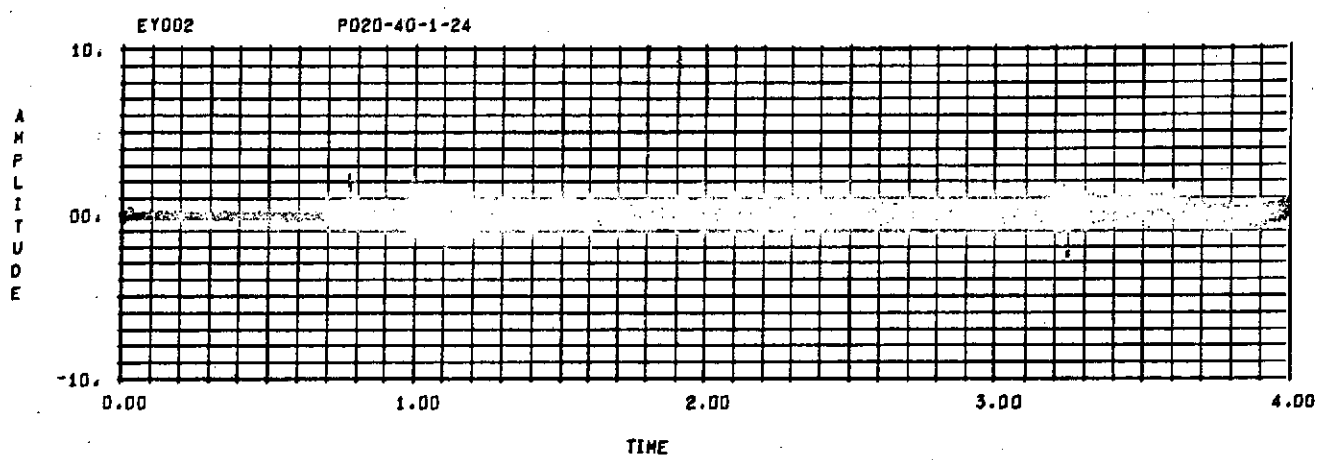
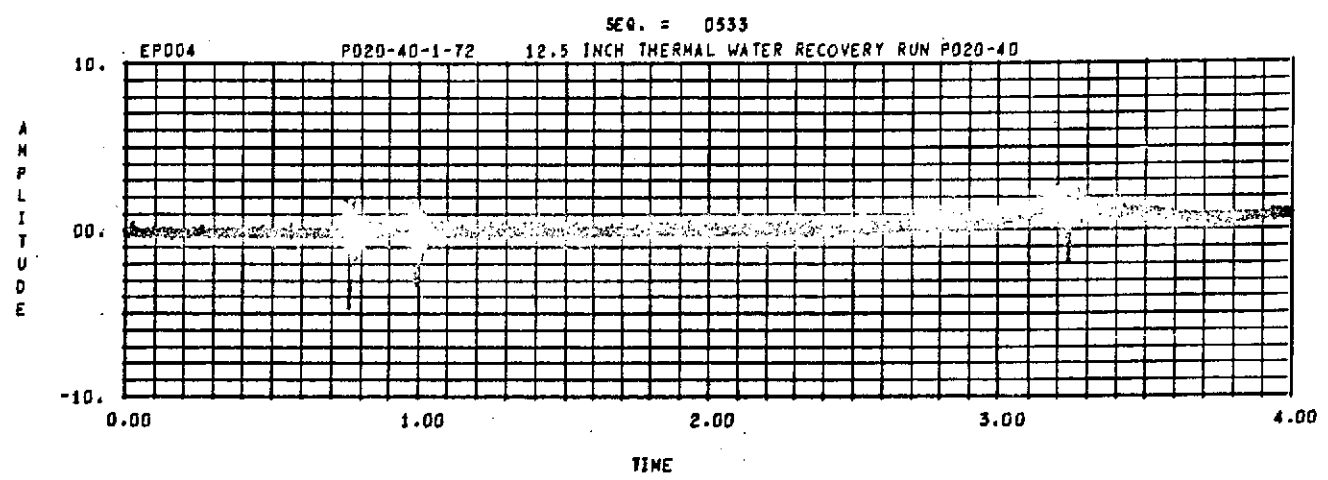




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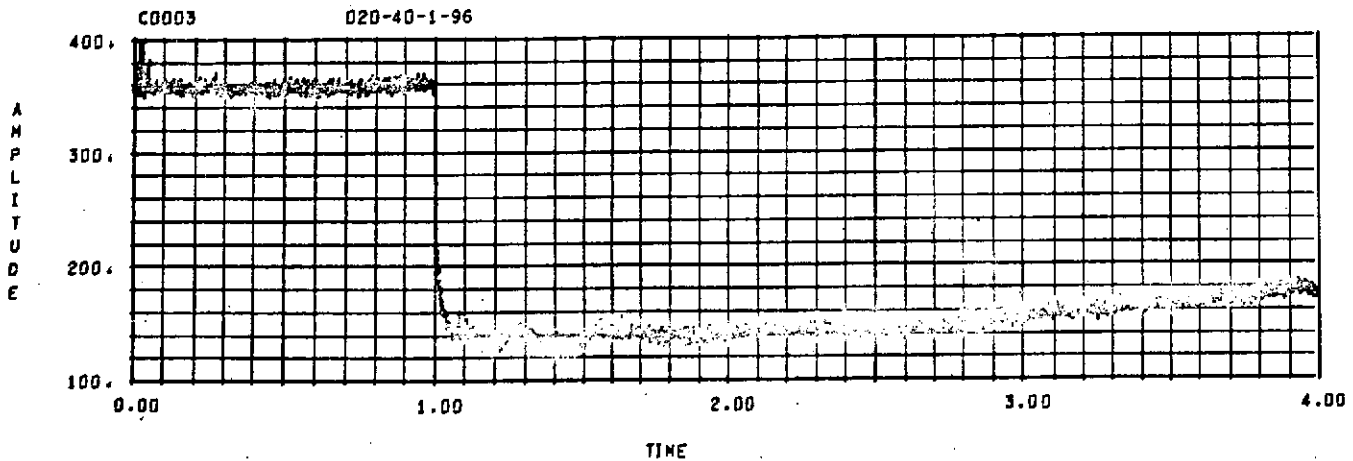
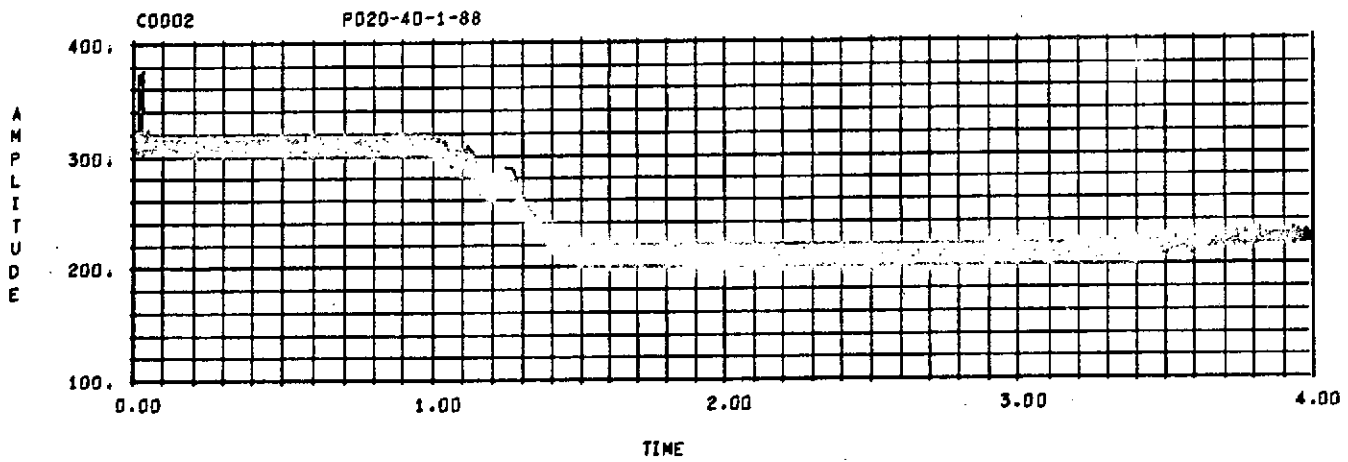
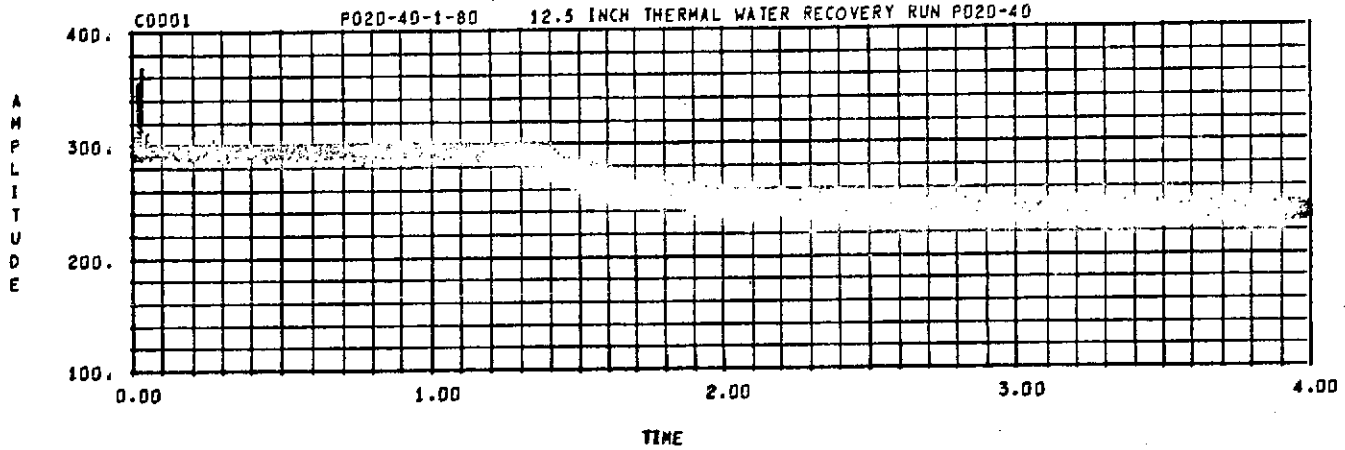
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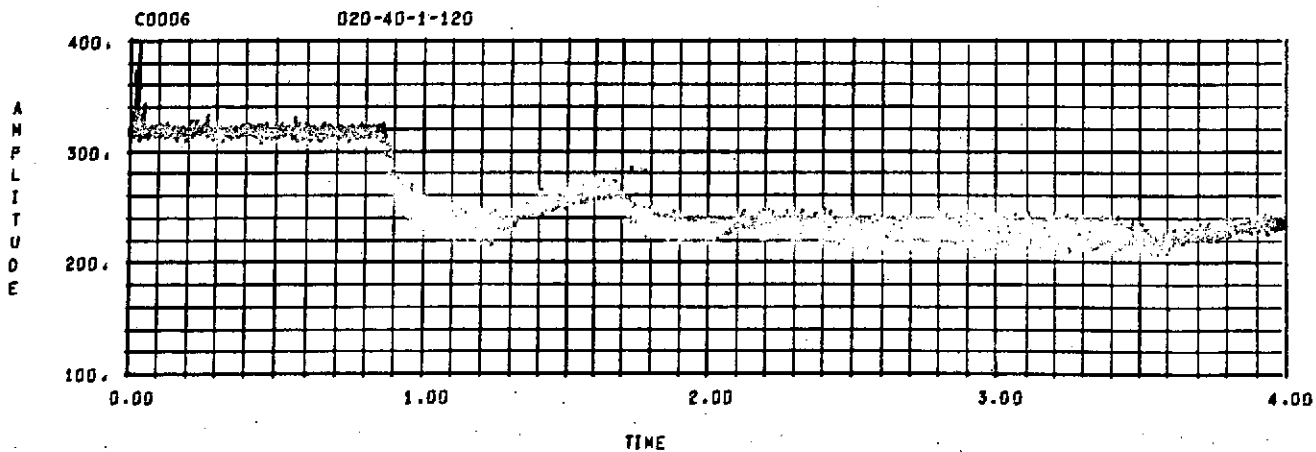
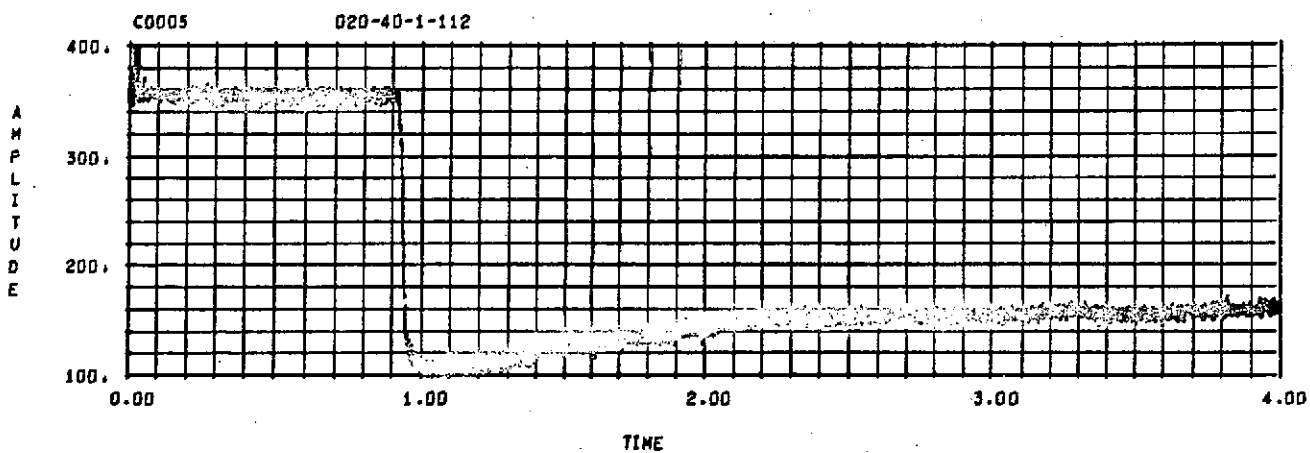
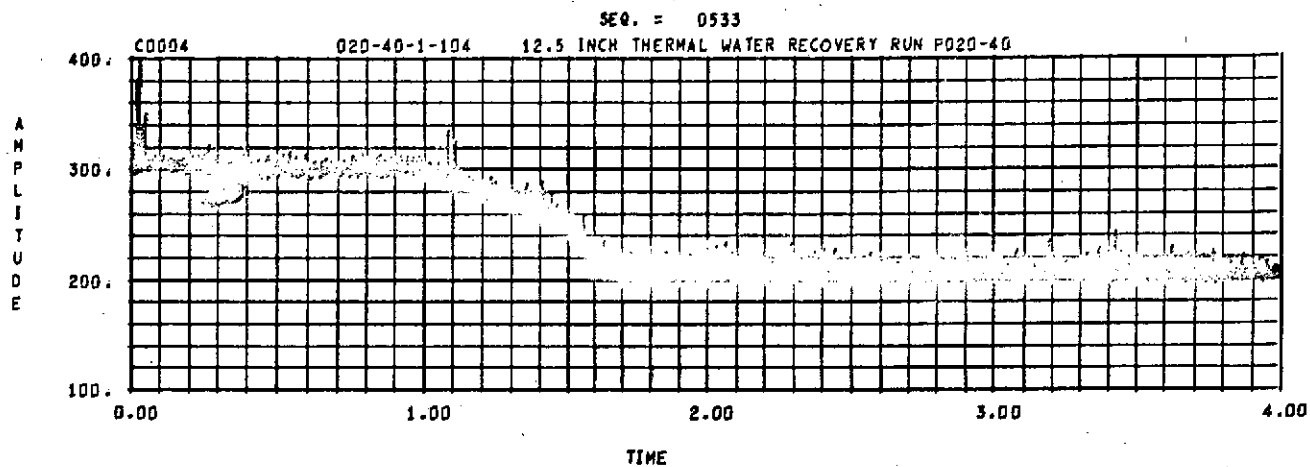


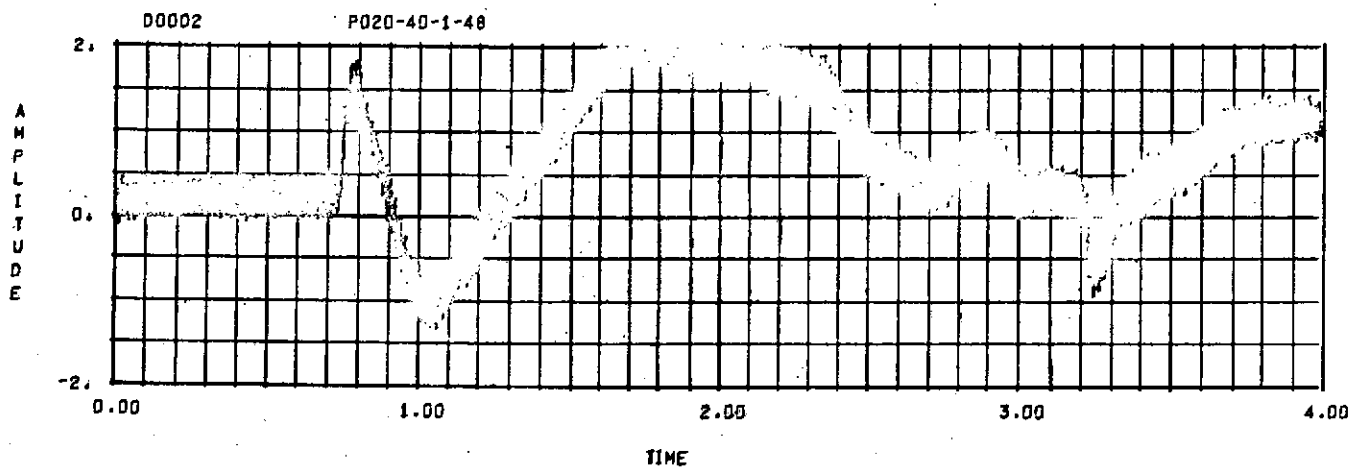
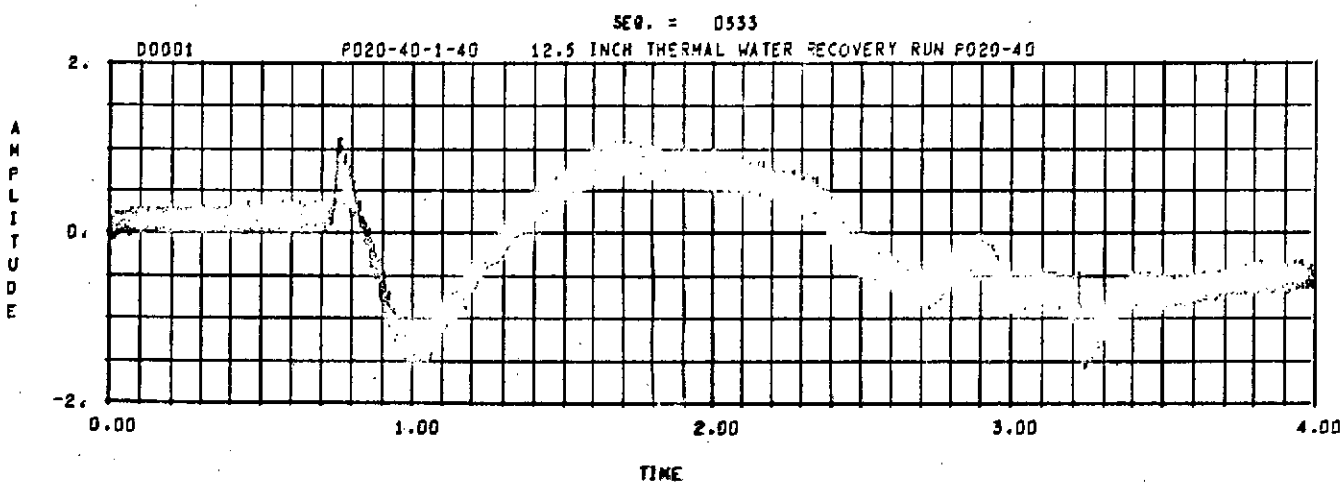
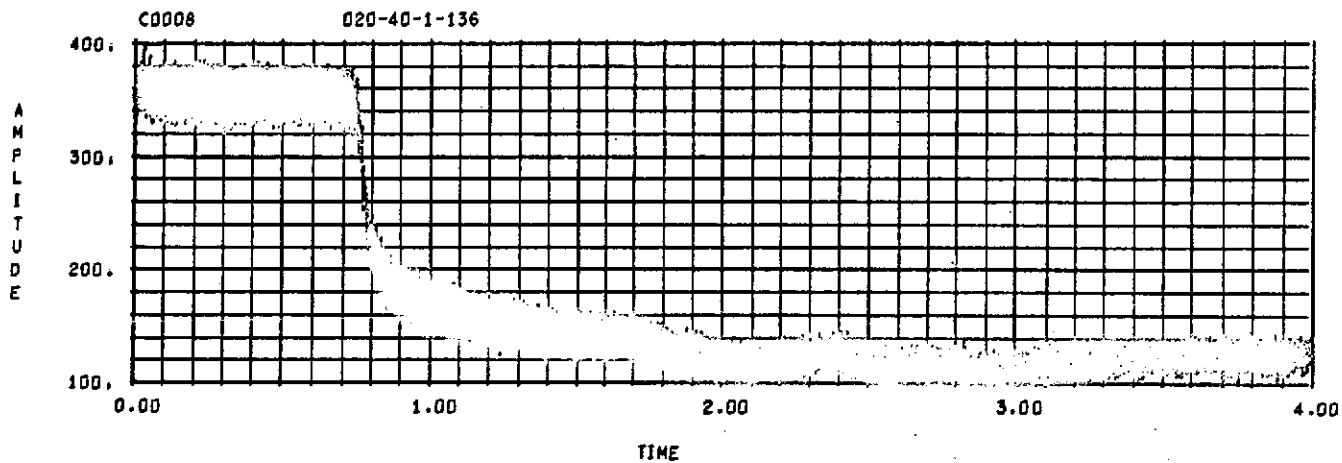


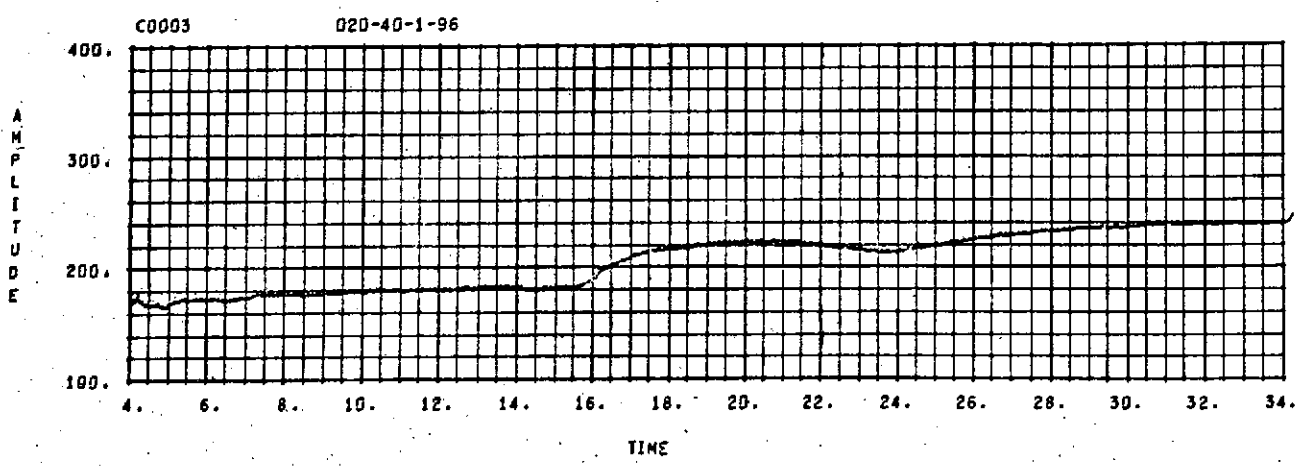
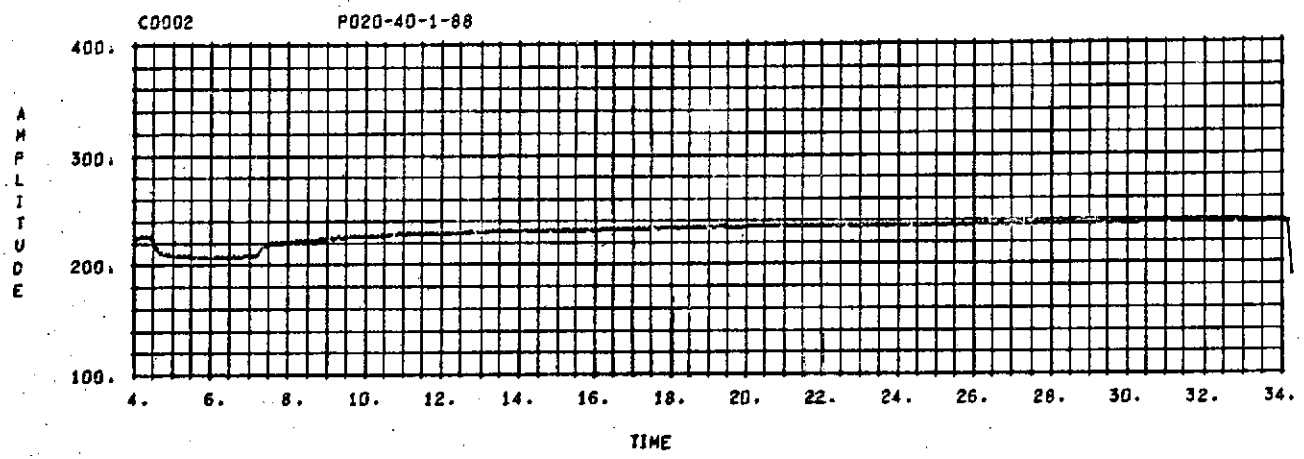
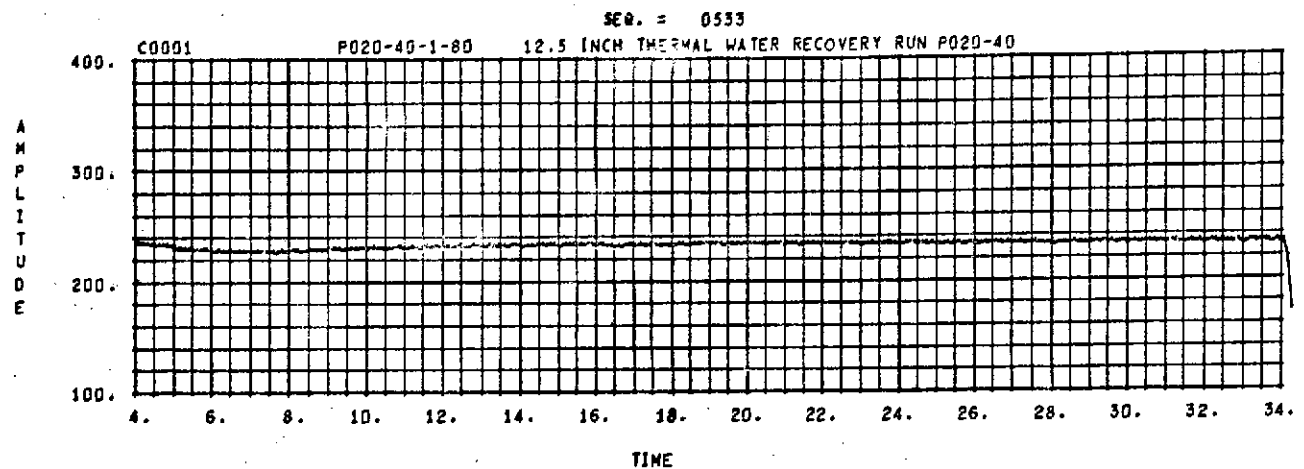
SER. = 0533

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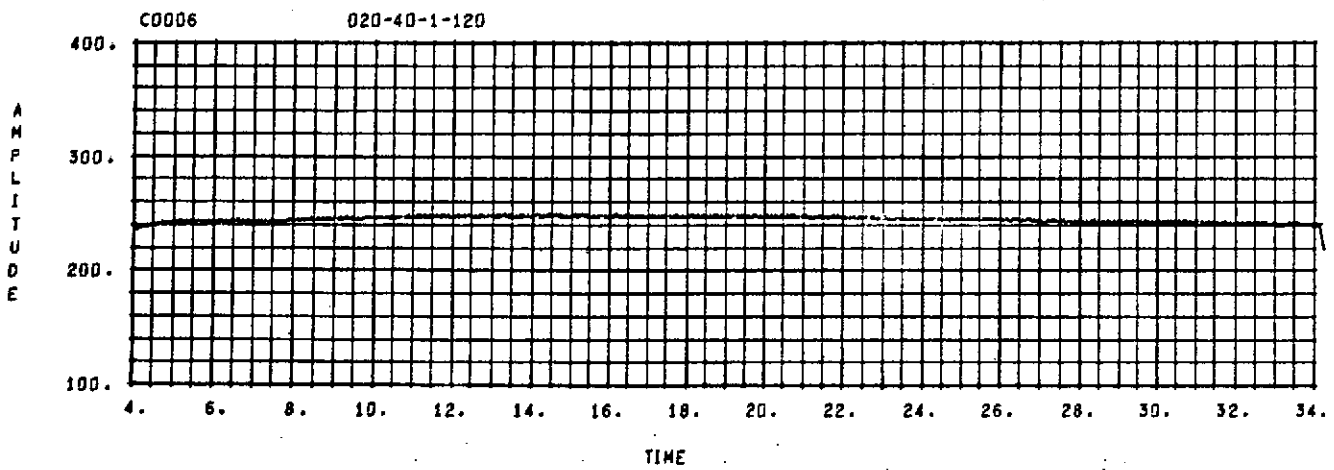
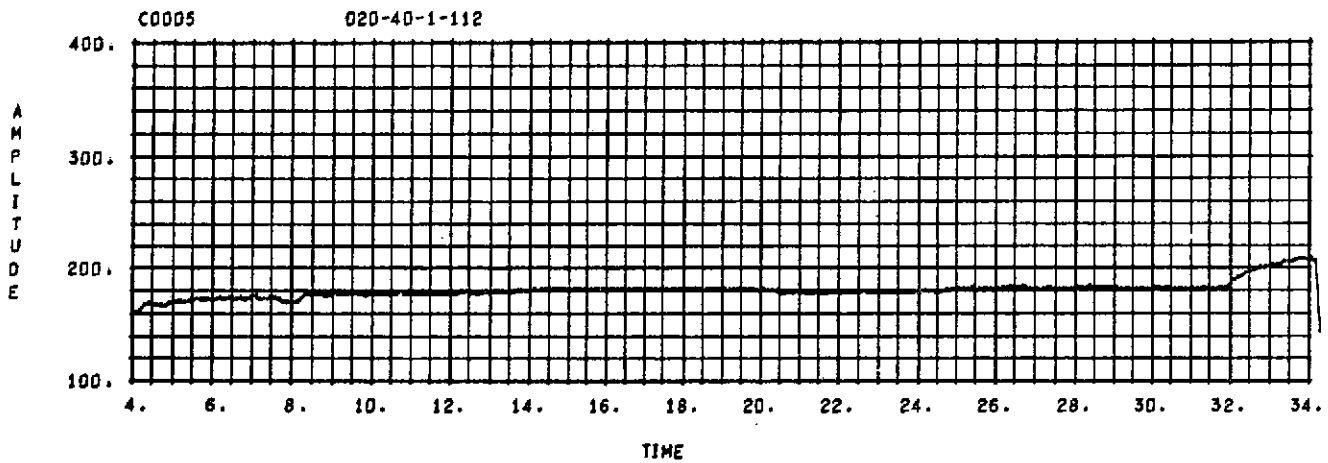
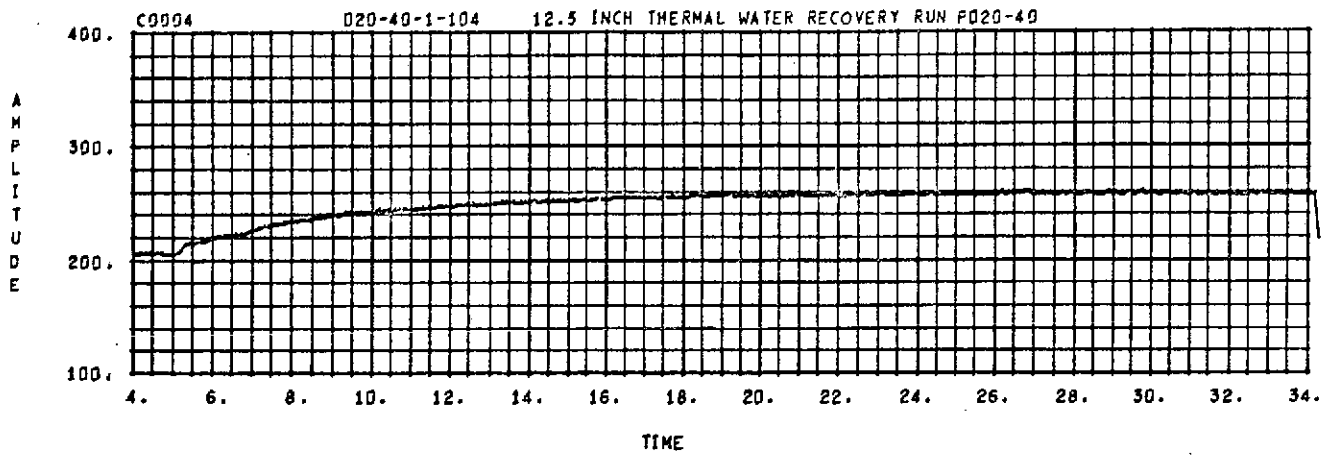


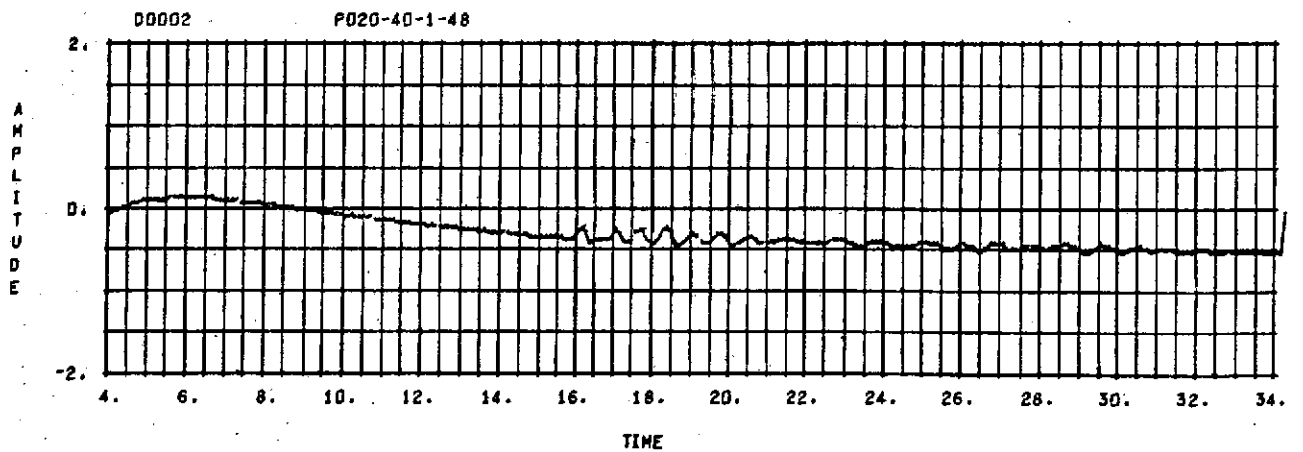
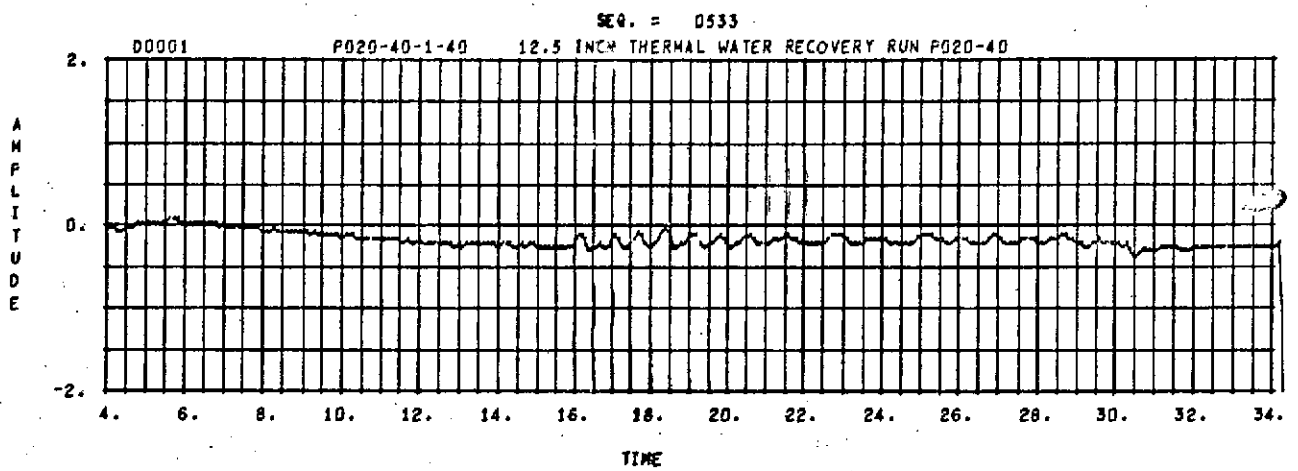
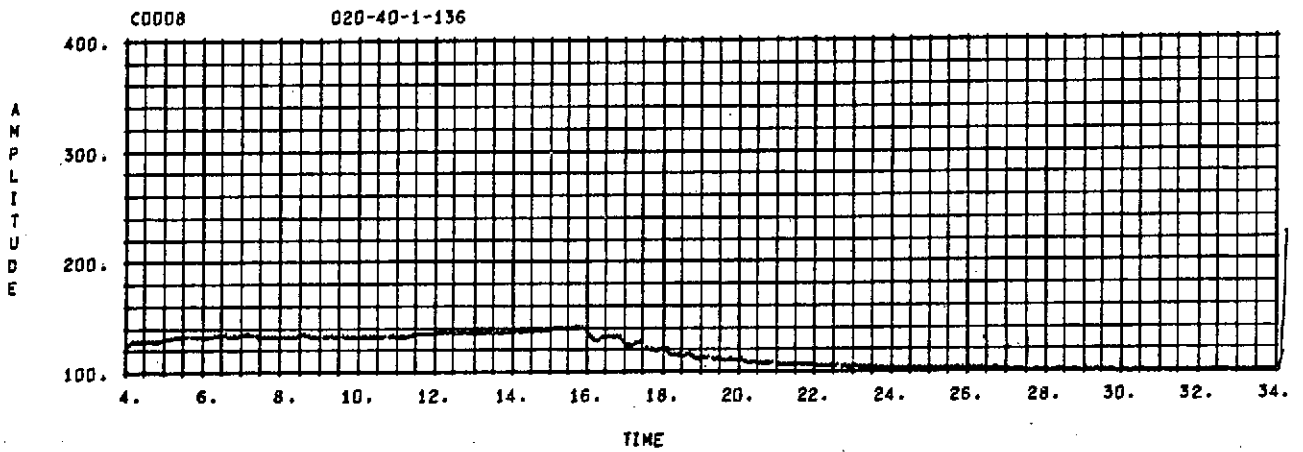




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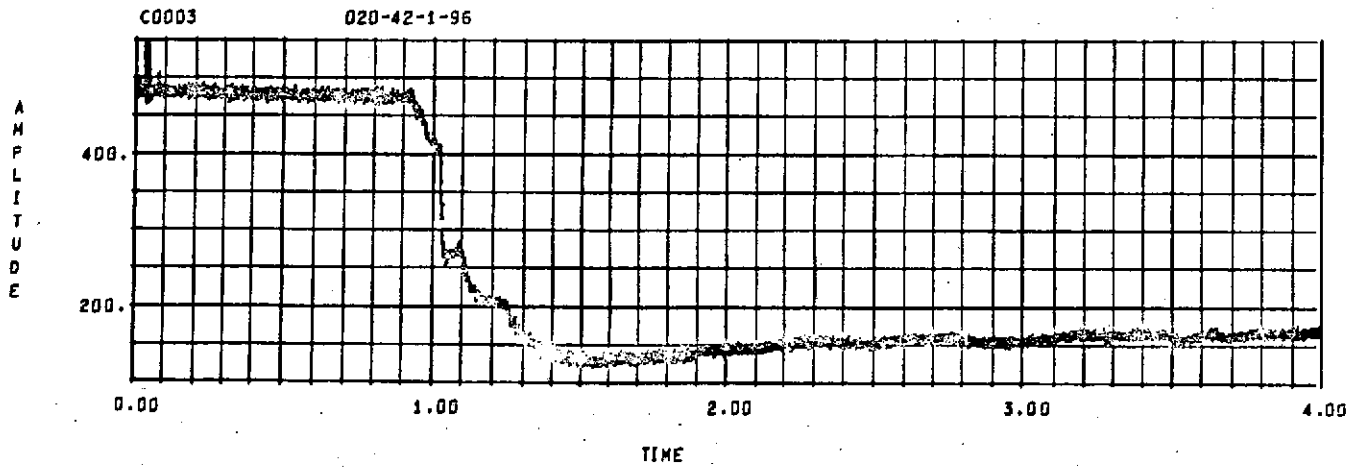
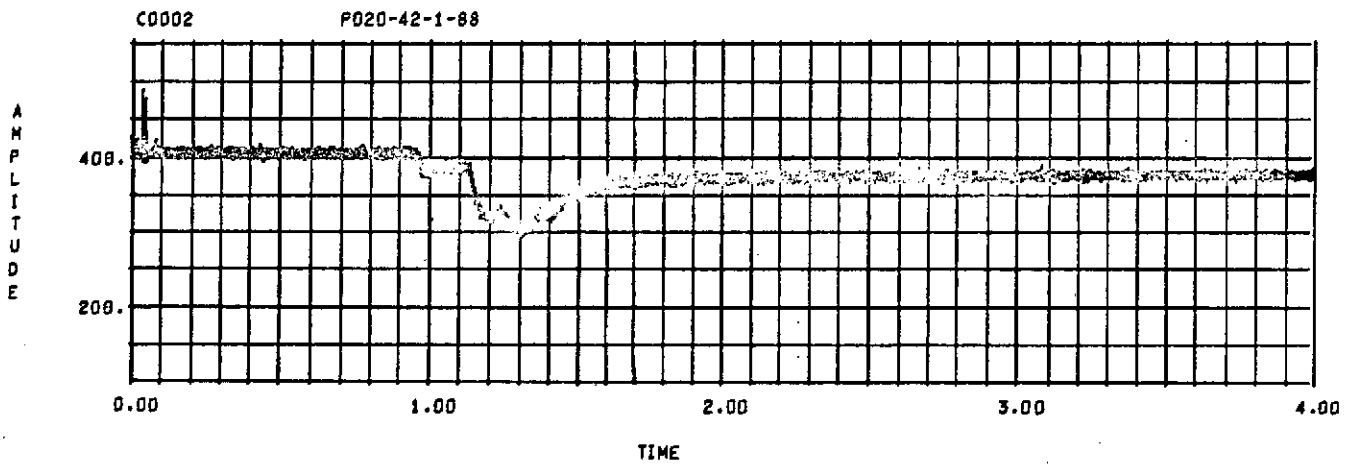
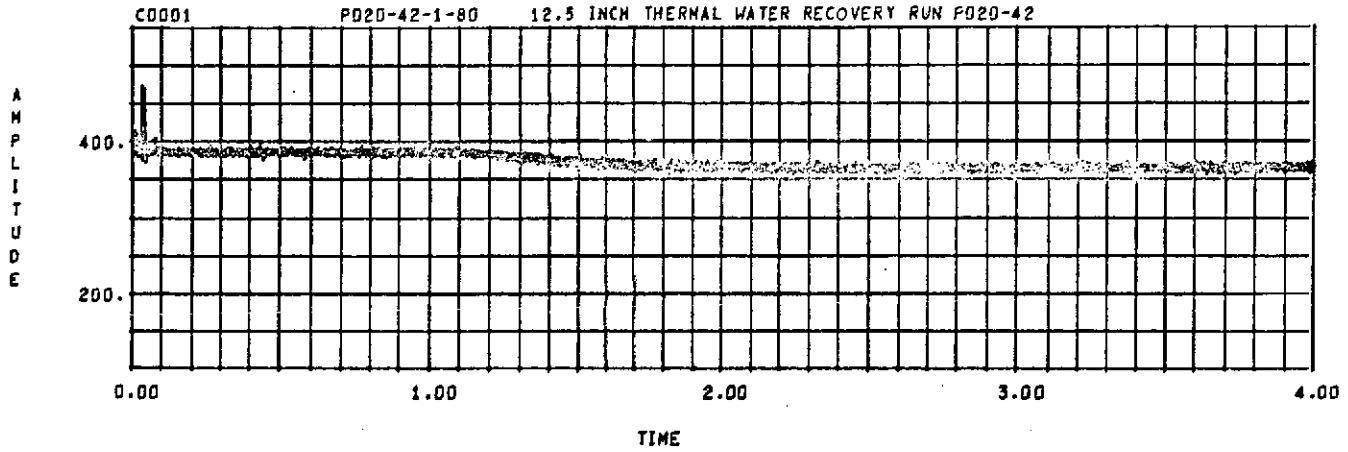
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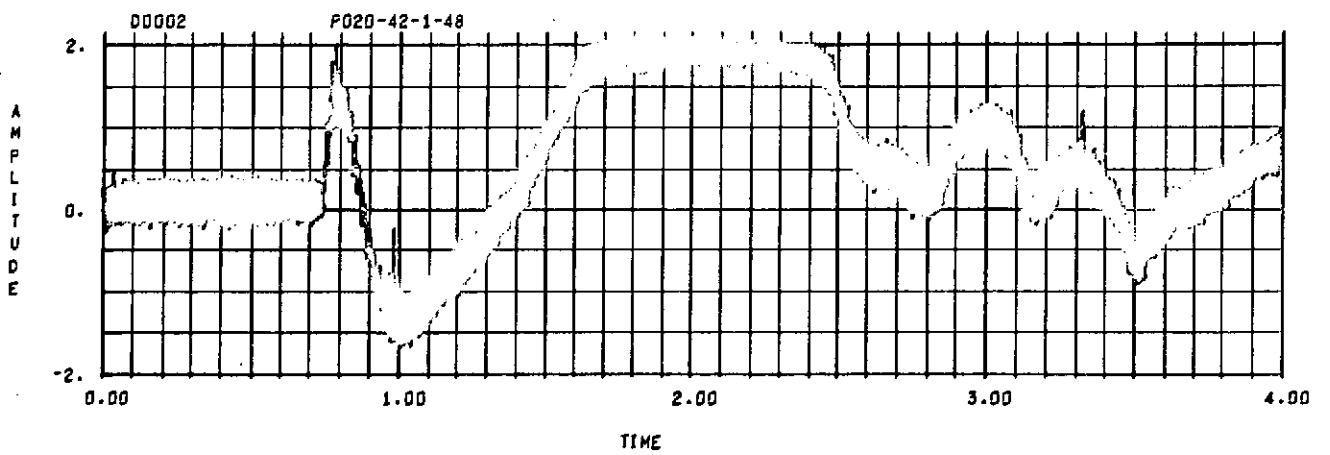
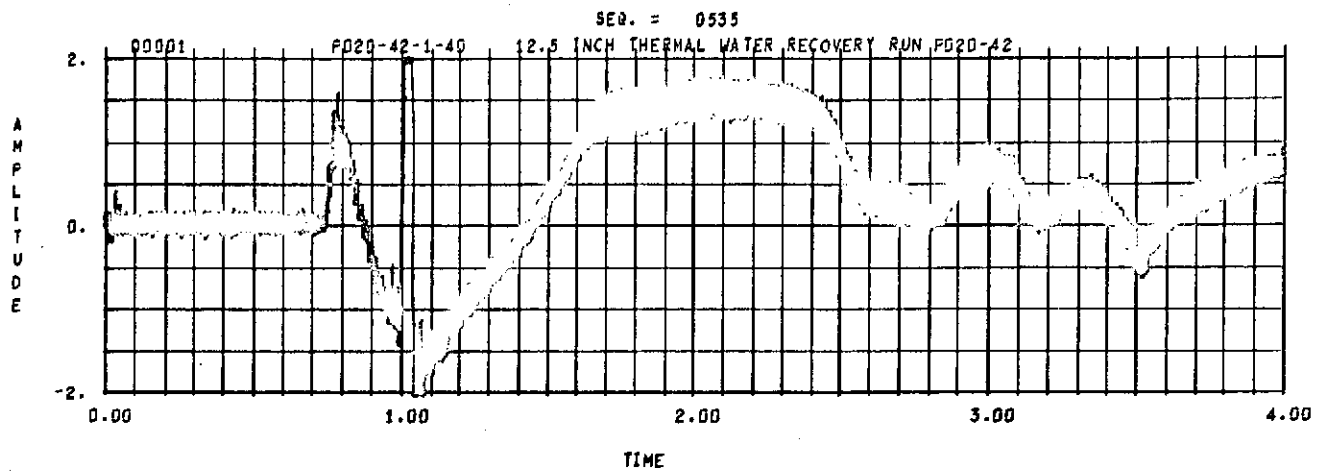




SEQ. = 0535

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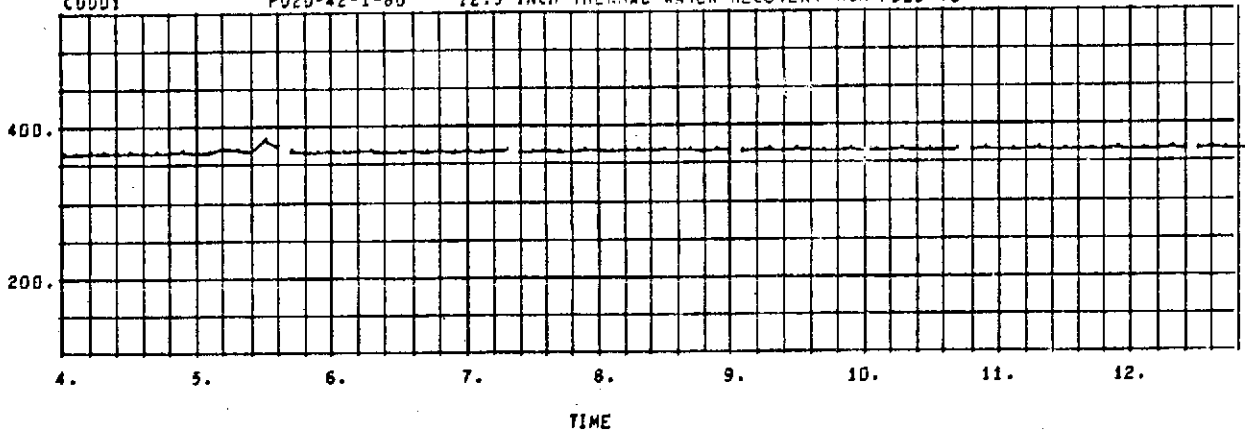


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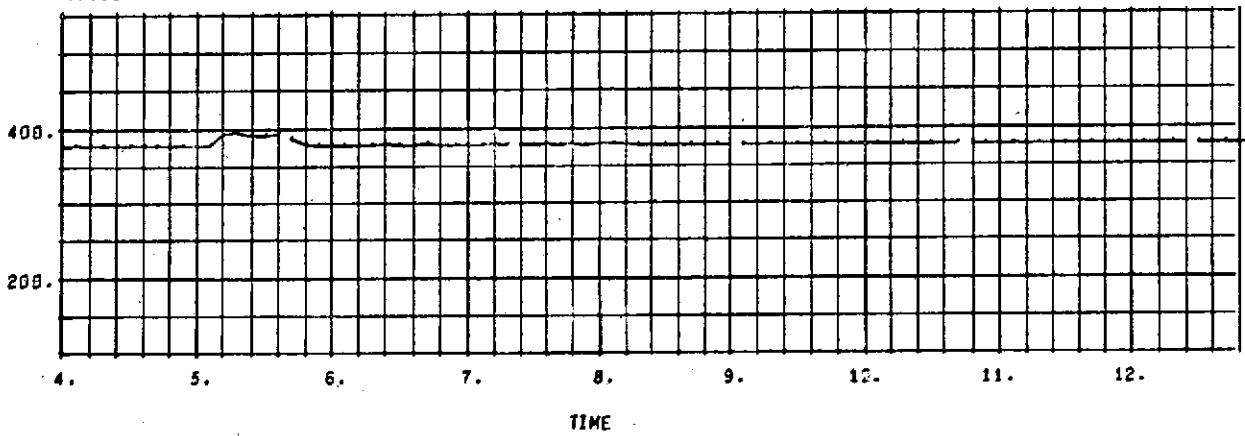
C0001 P020-42-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-42

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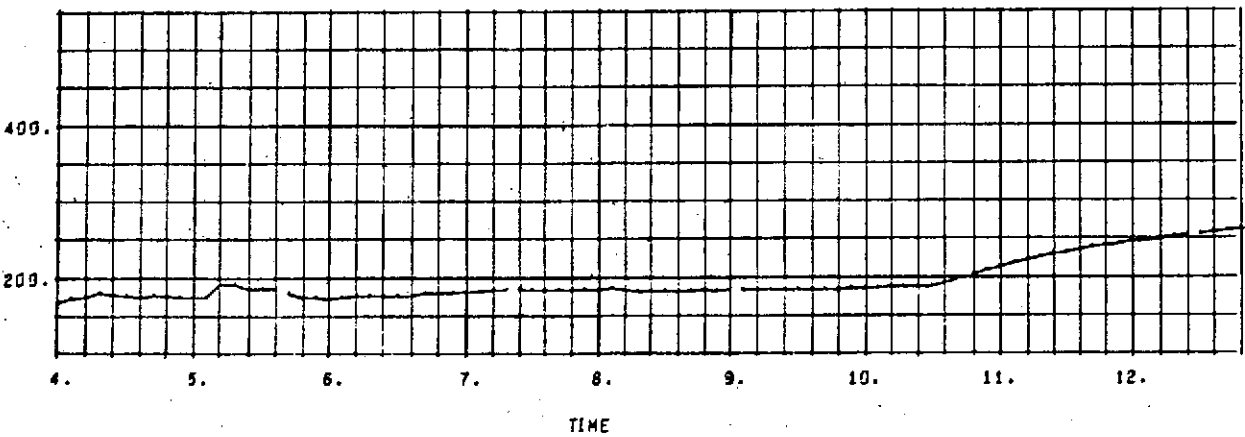
C0002 P020-42-1-88

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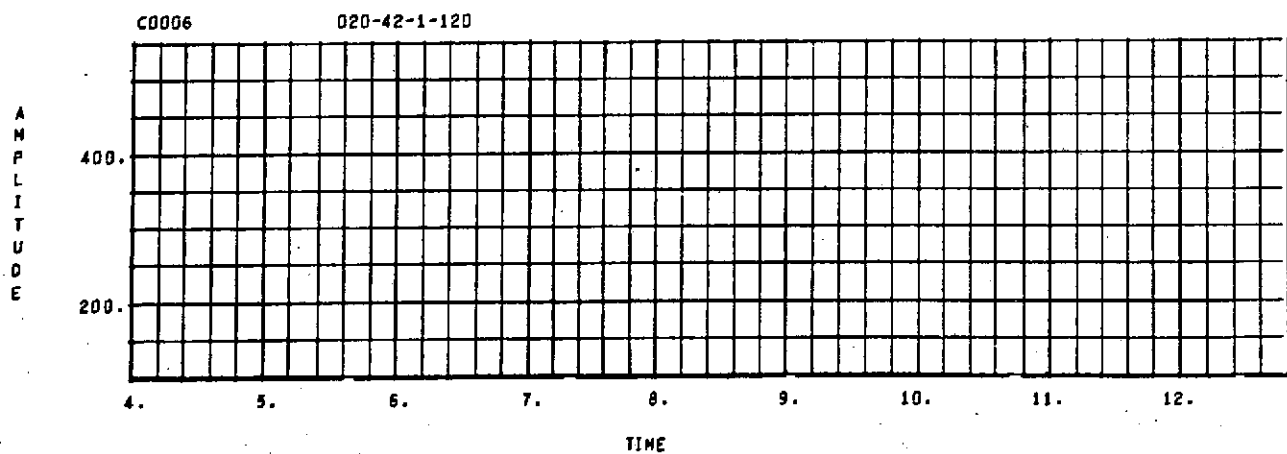
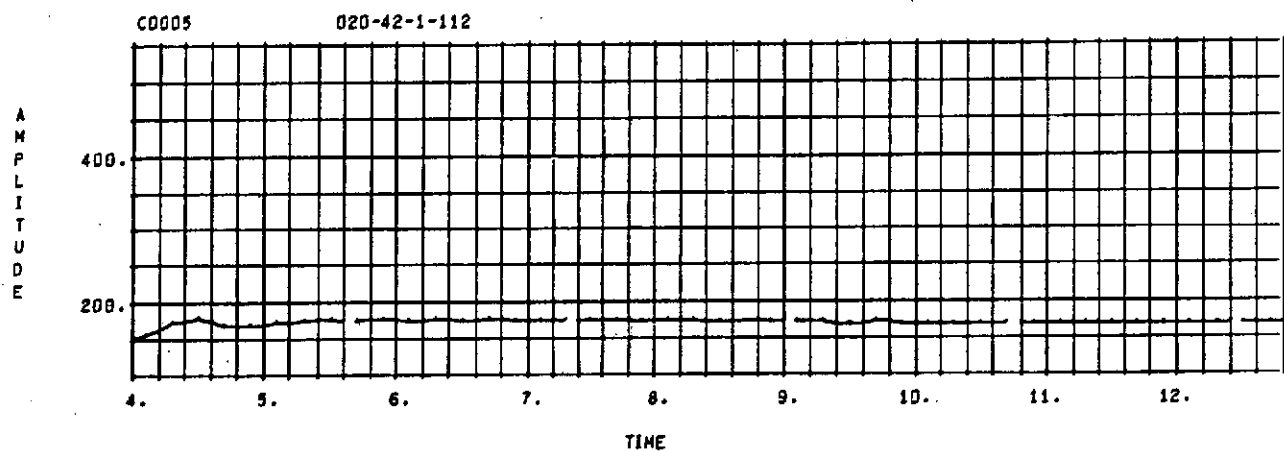
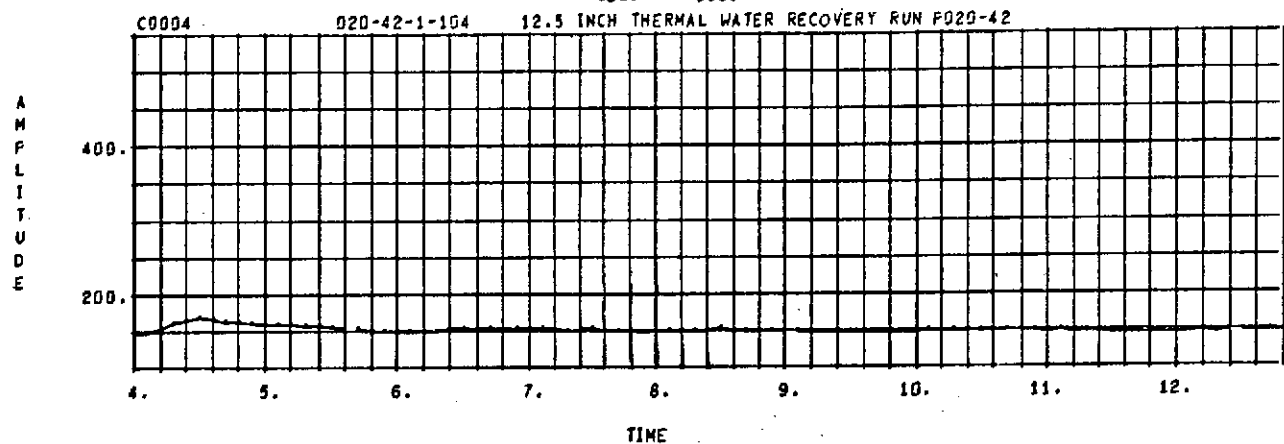


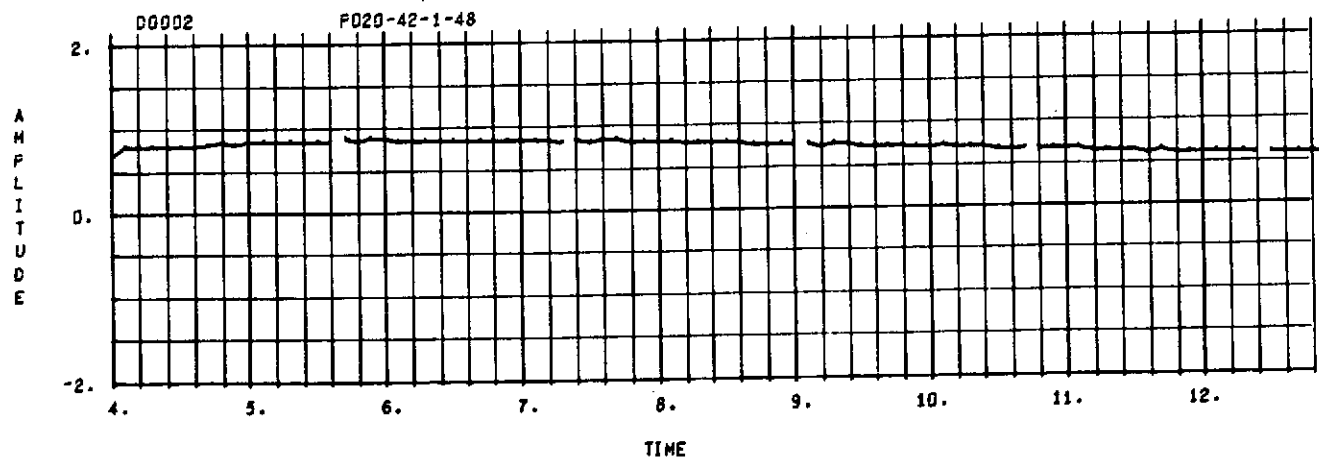
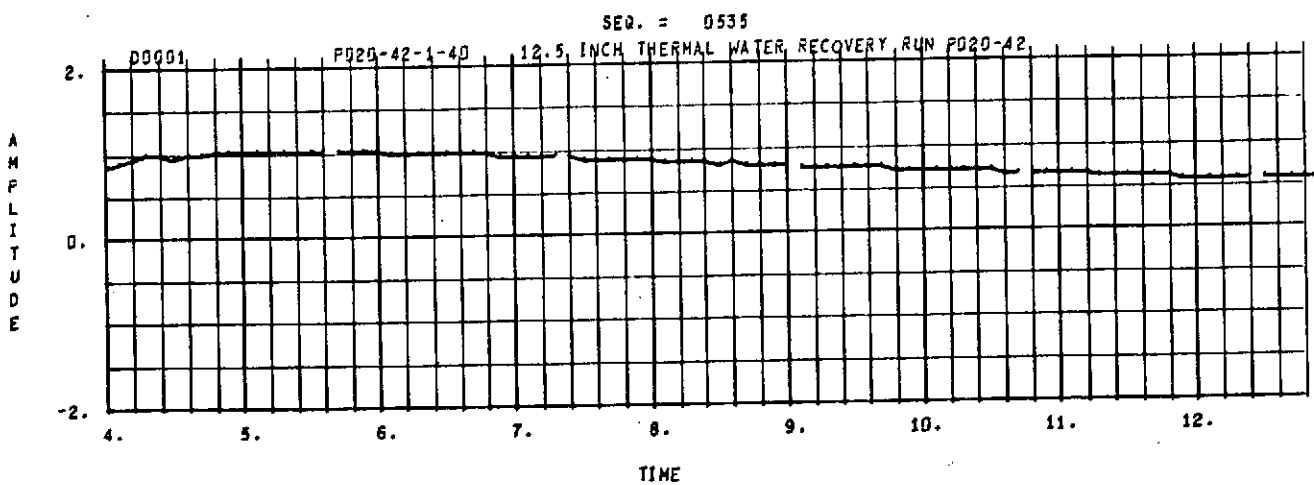
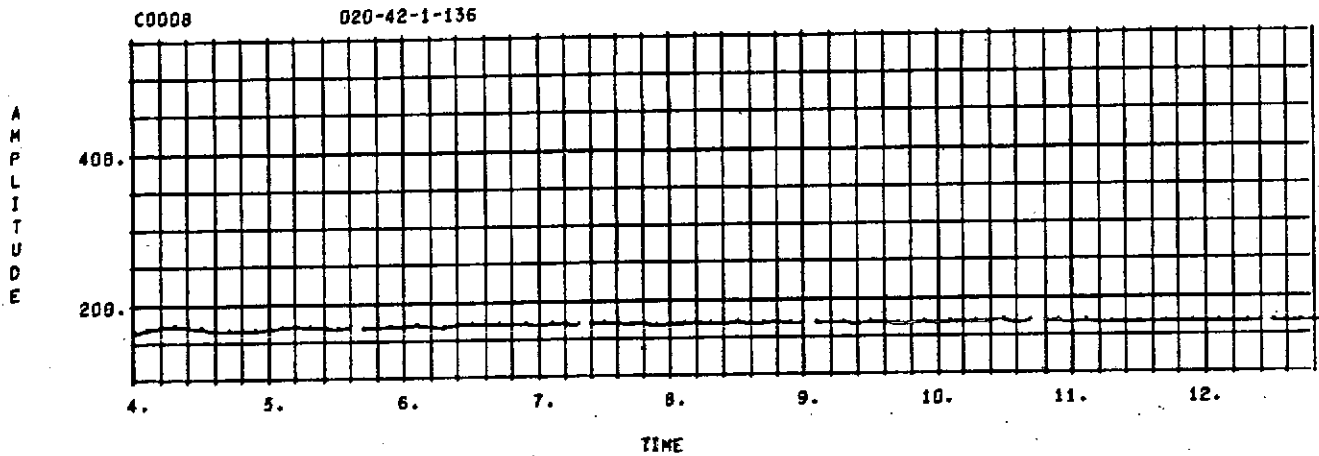
C0003 020-42-1-96

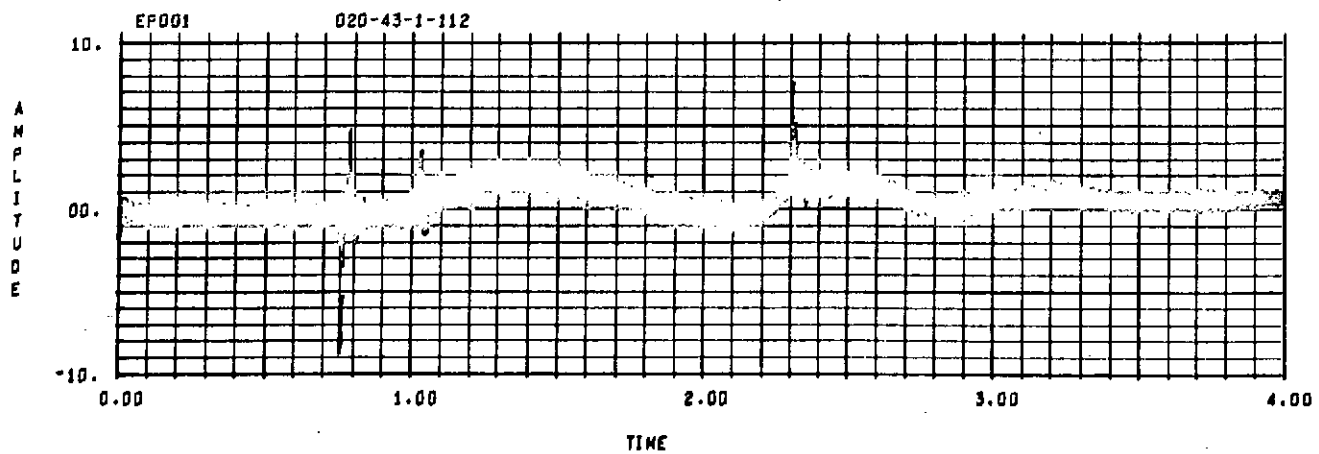
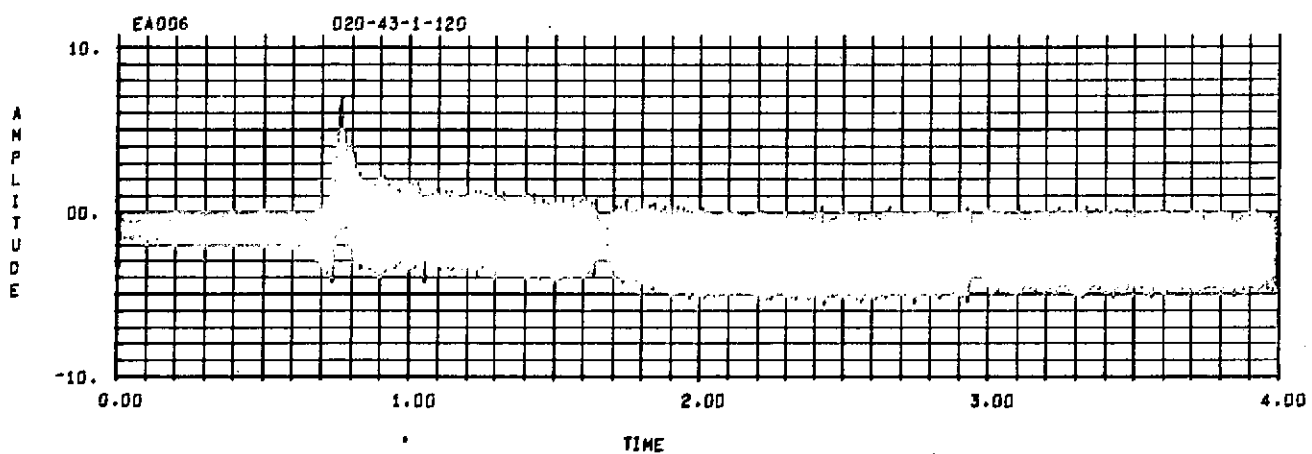
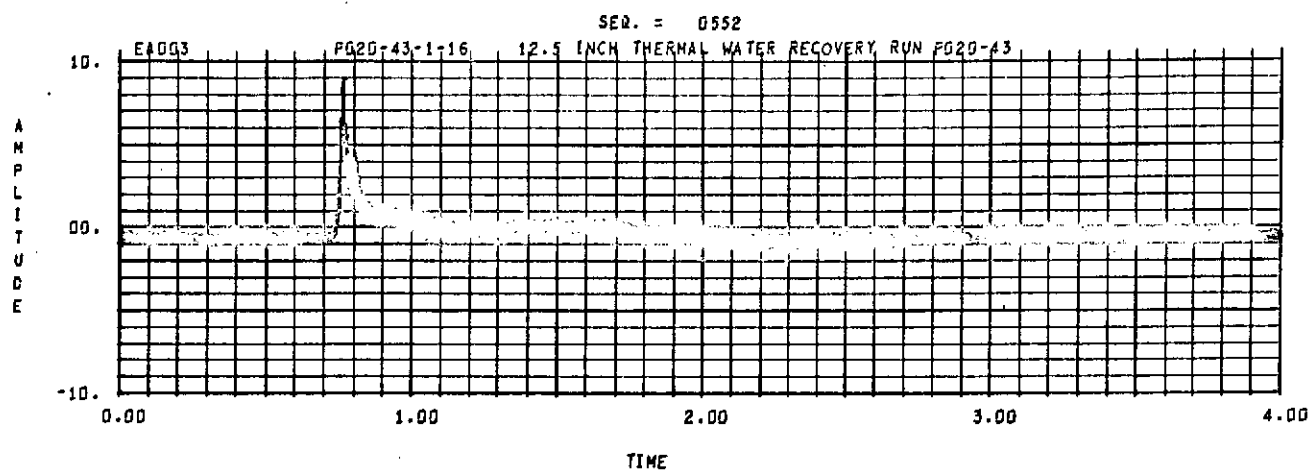
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SEQ. = 0535

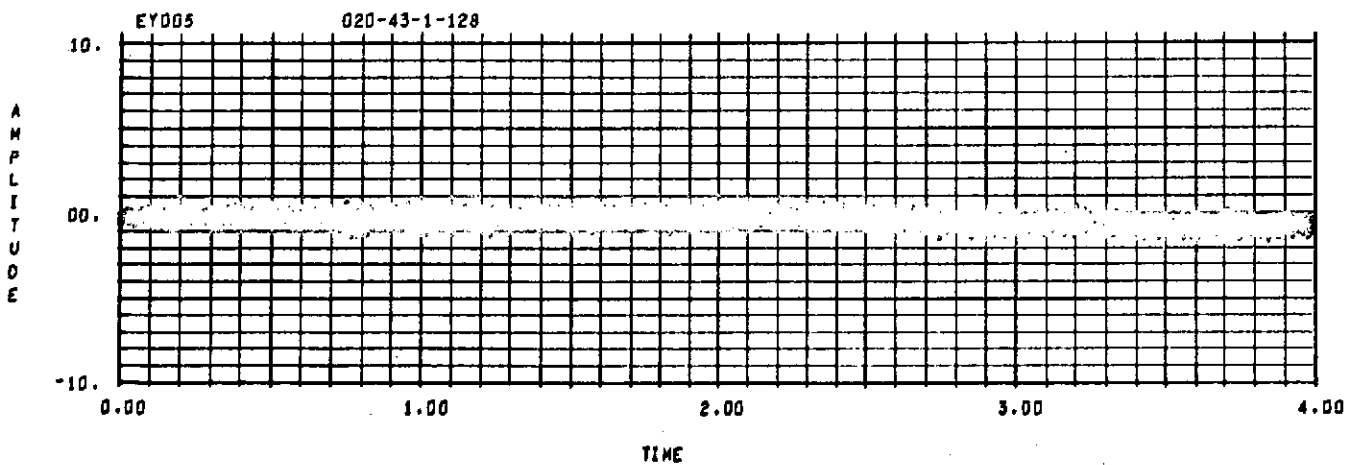
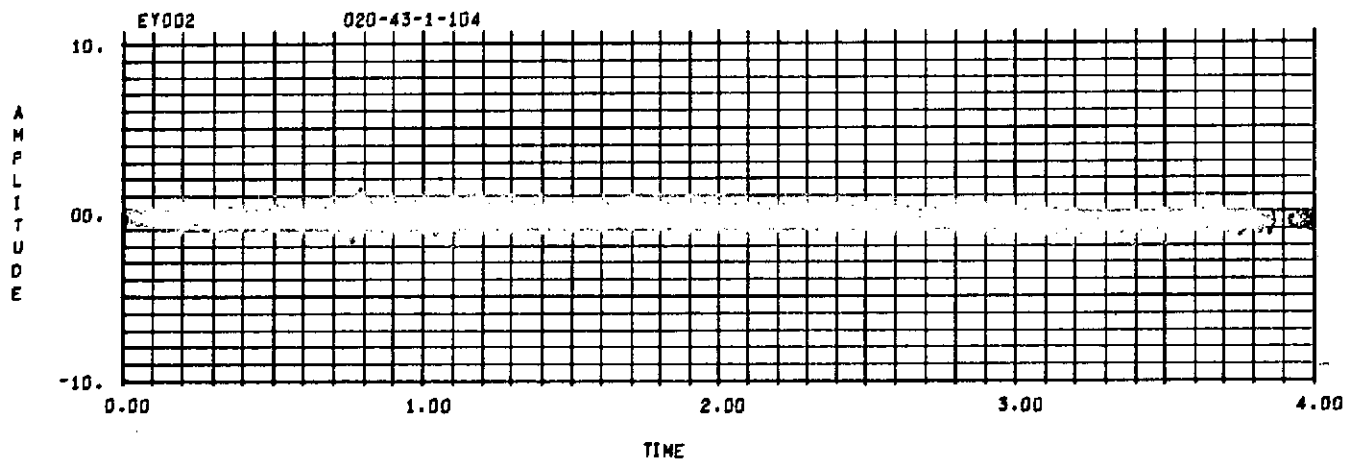
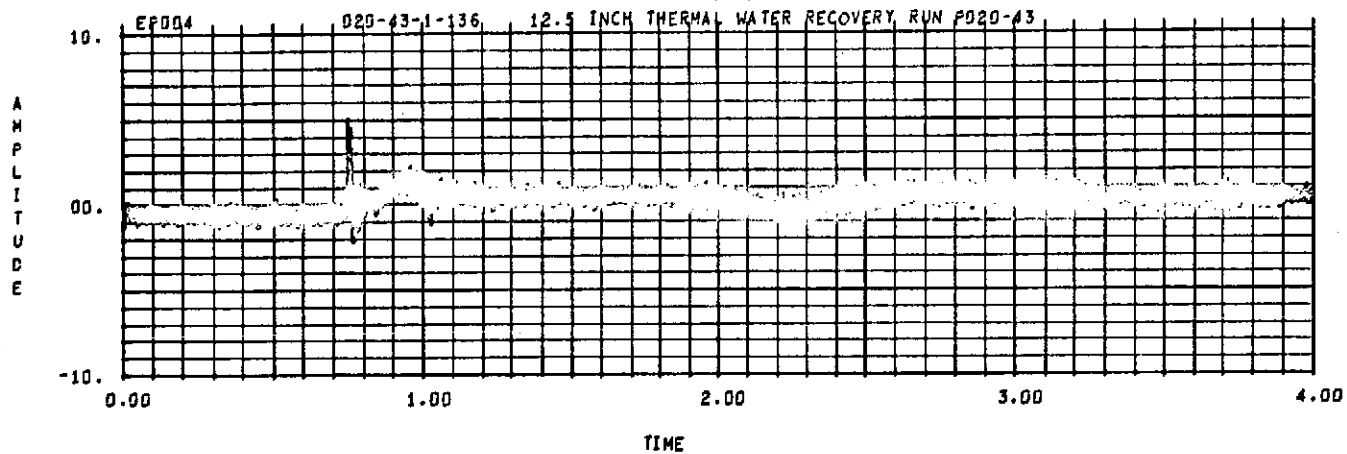


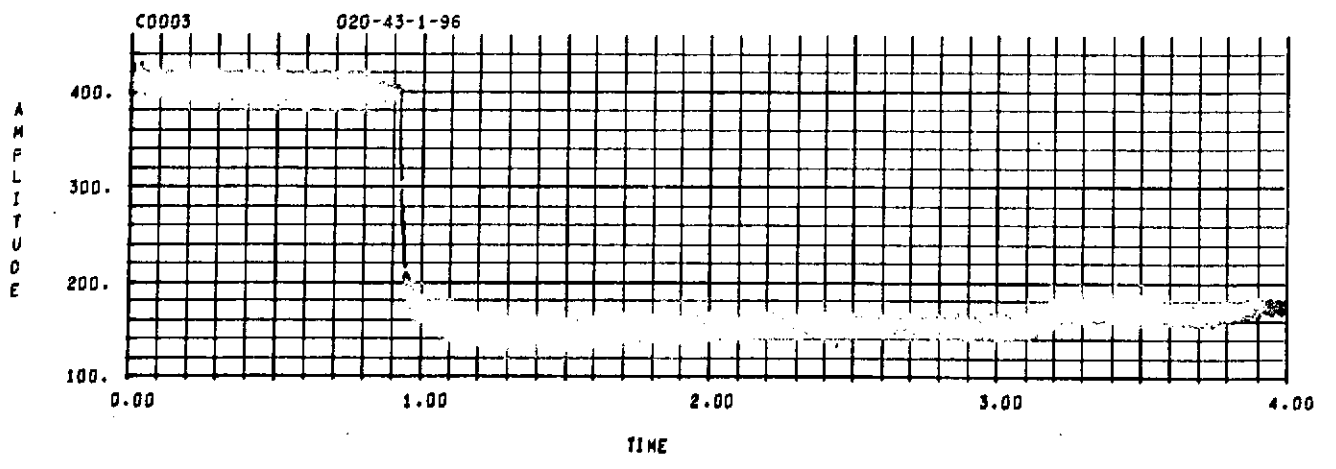
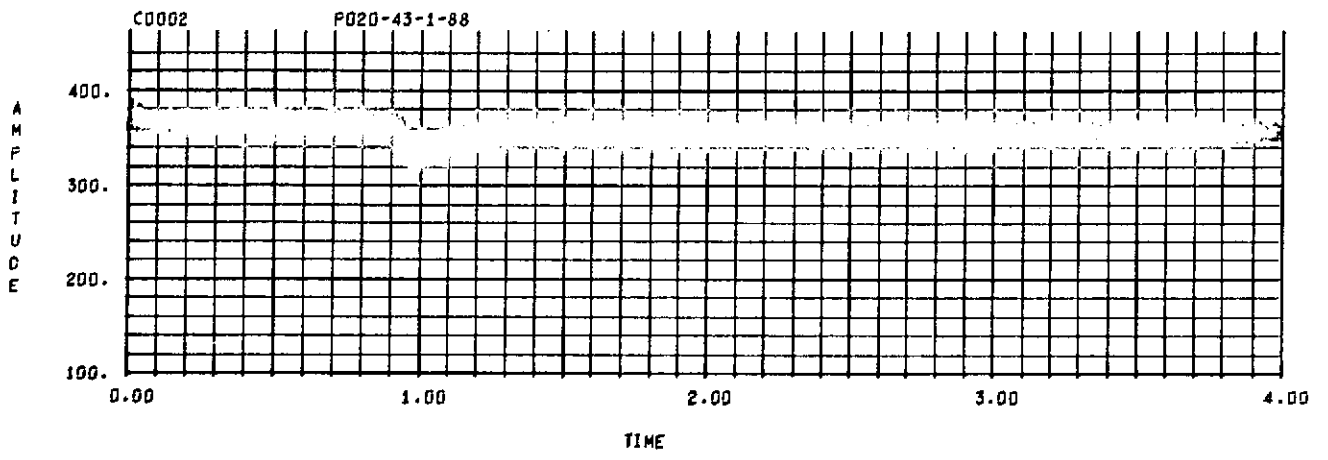
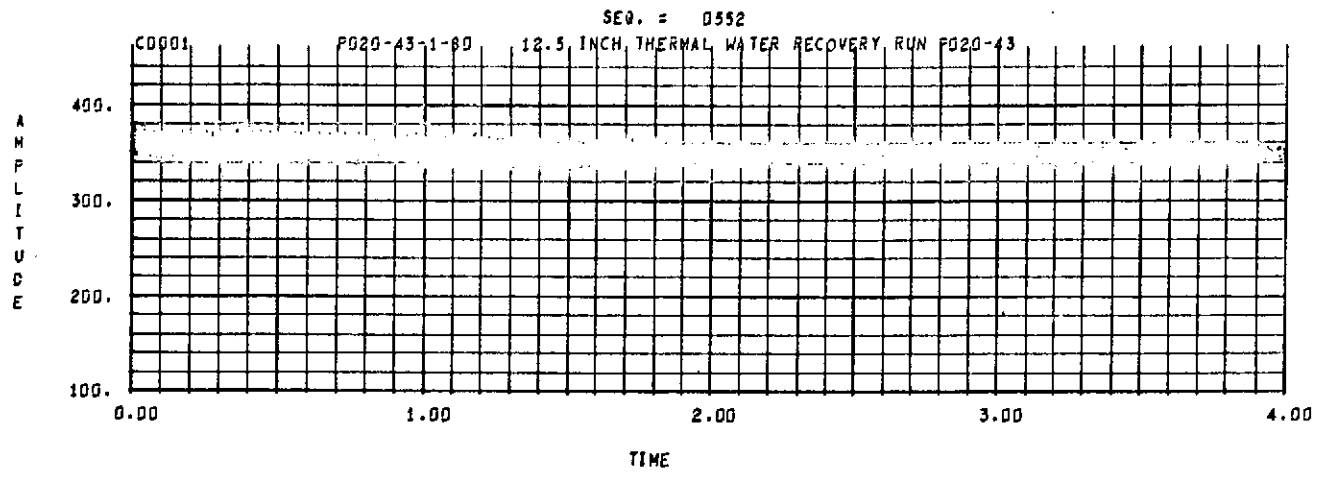


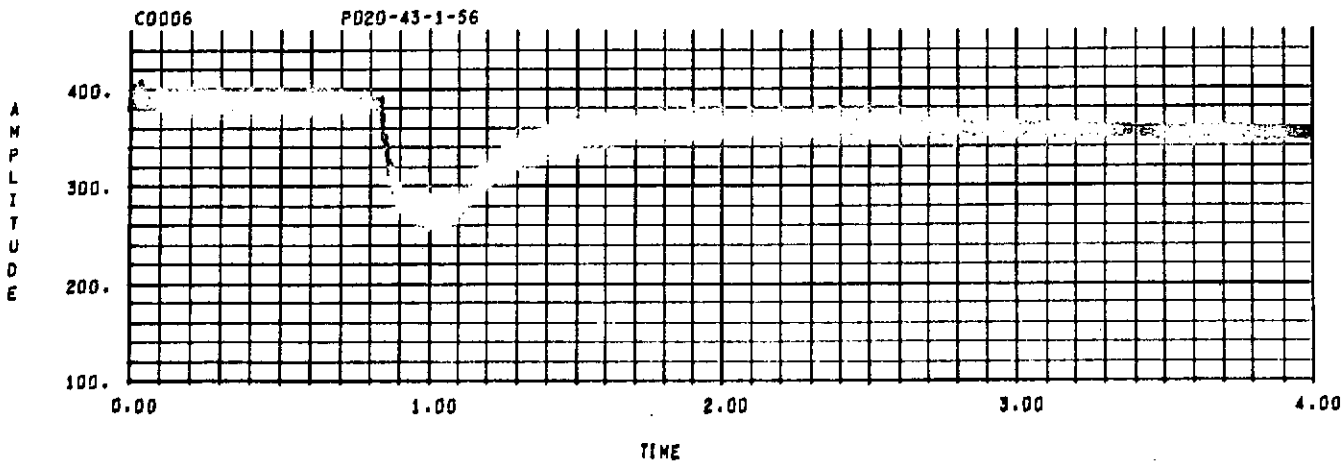
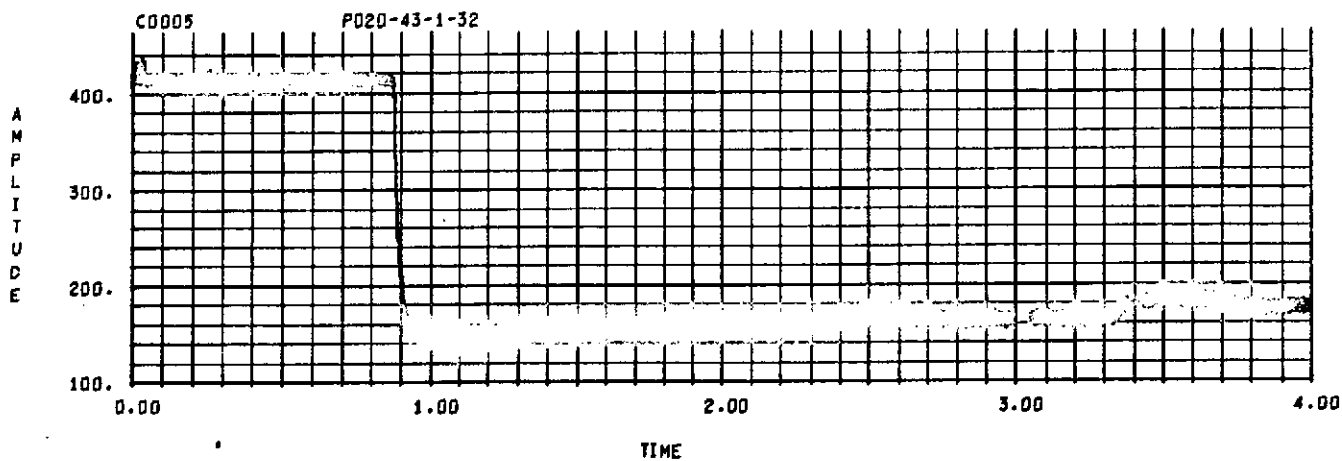
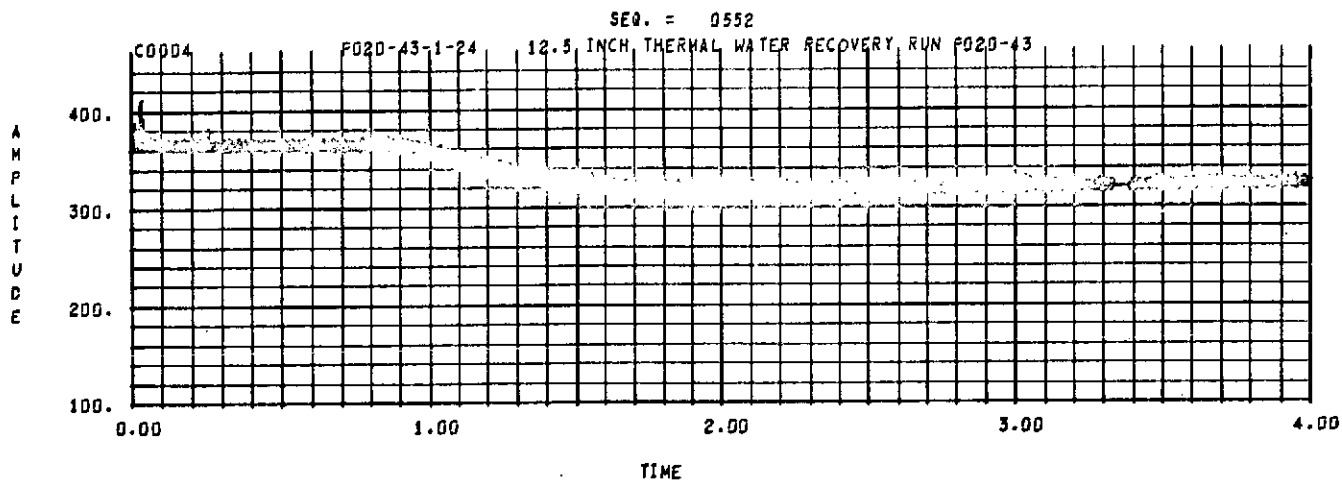


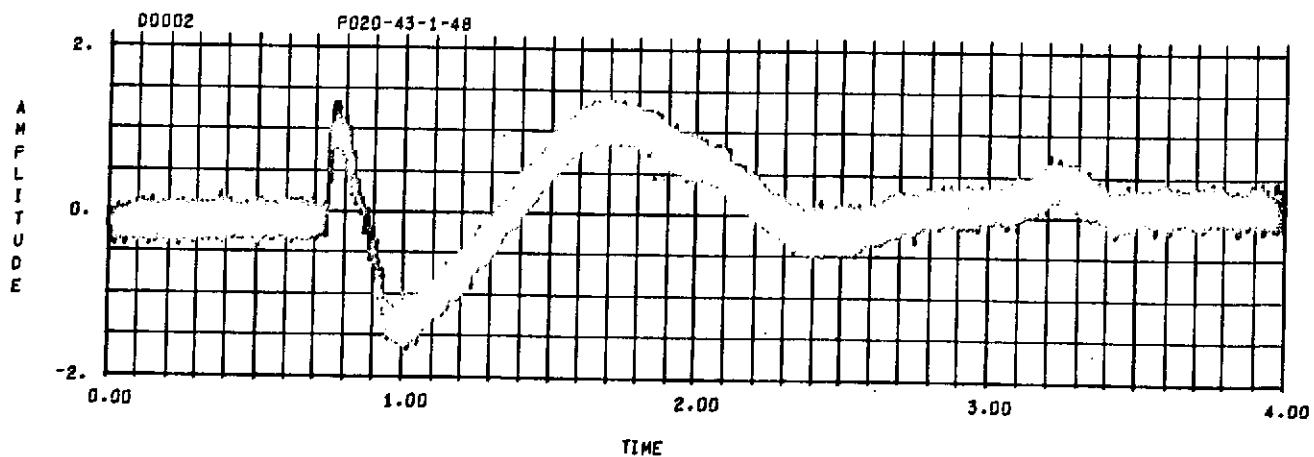
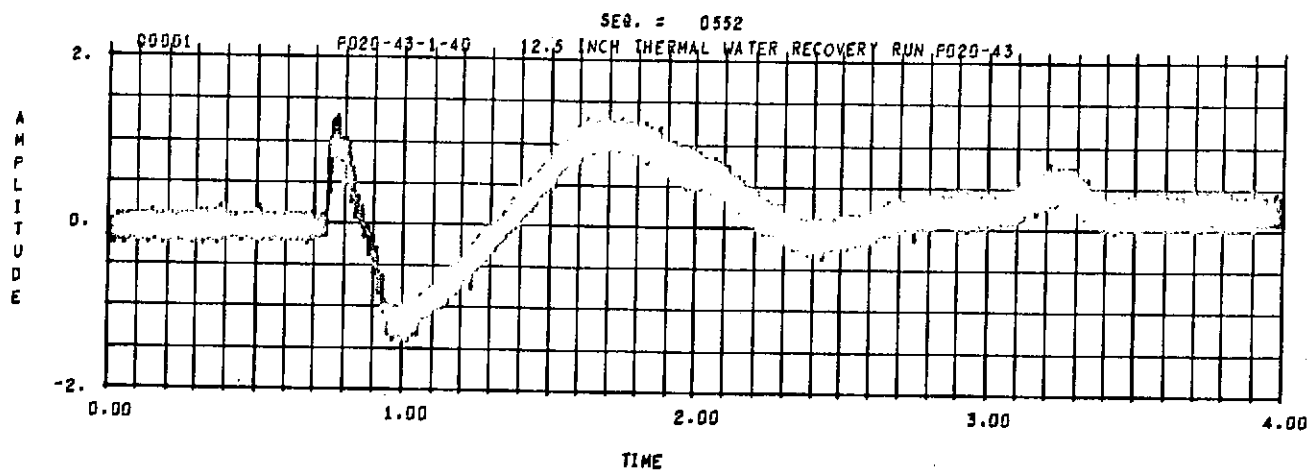
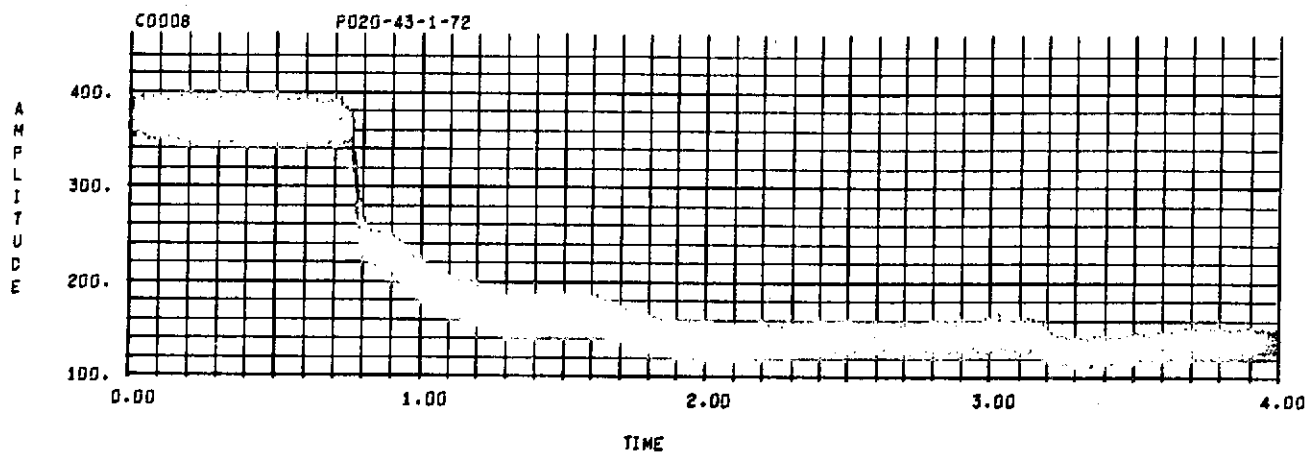
SEQ. = 0552

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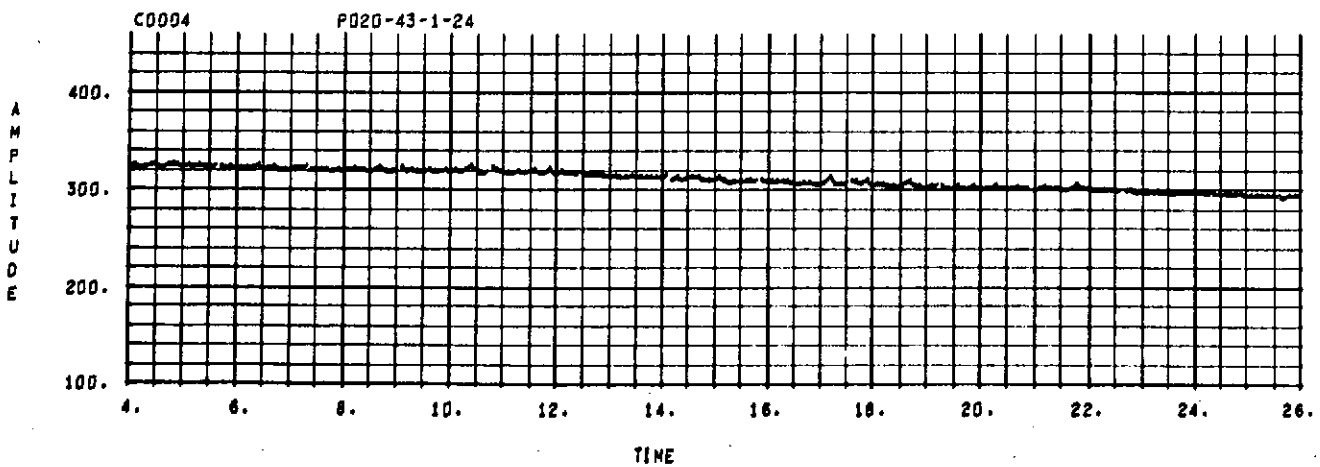
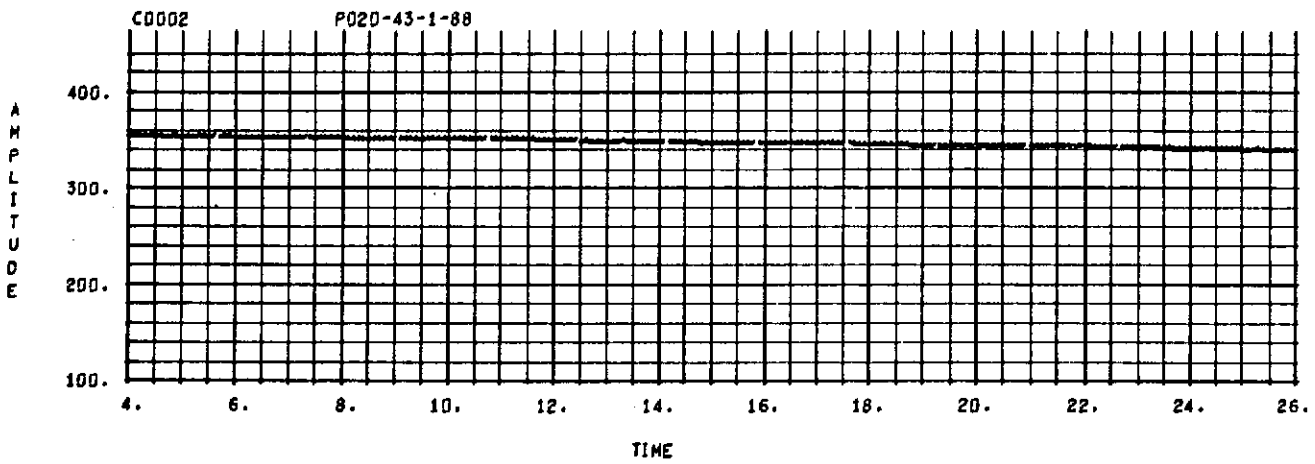
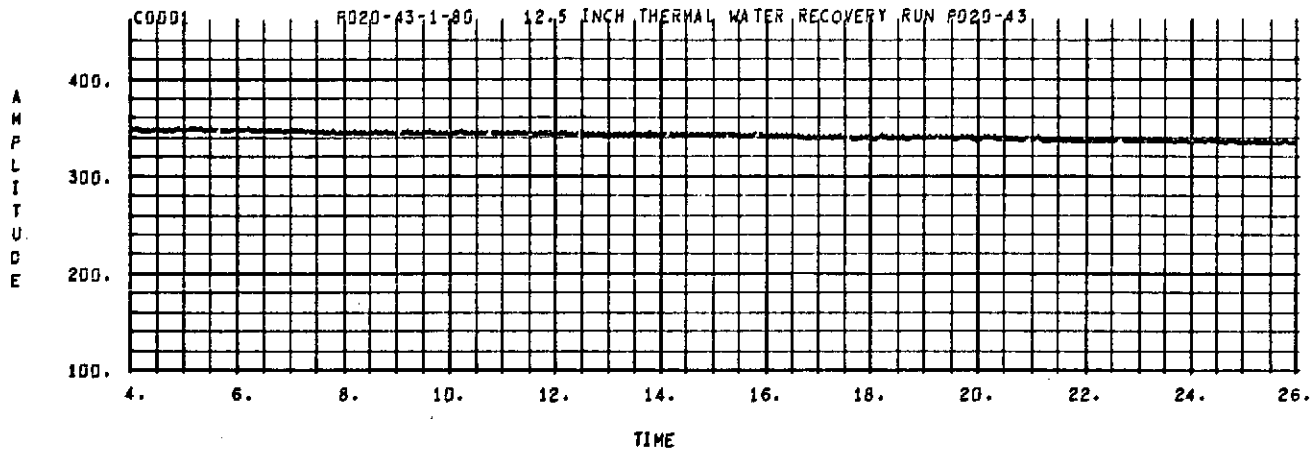


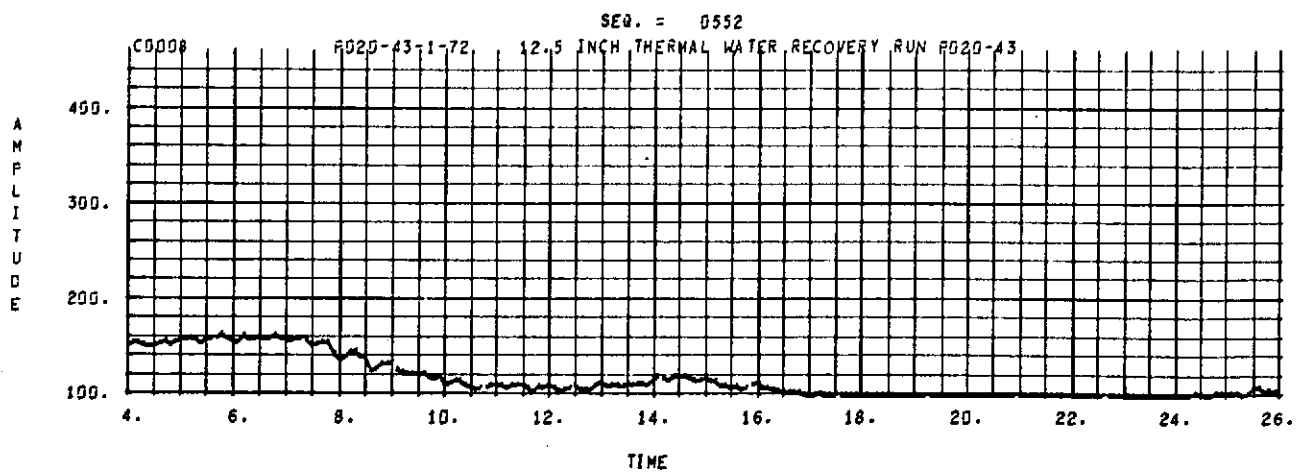
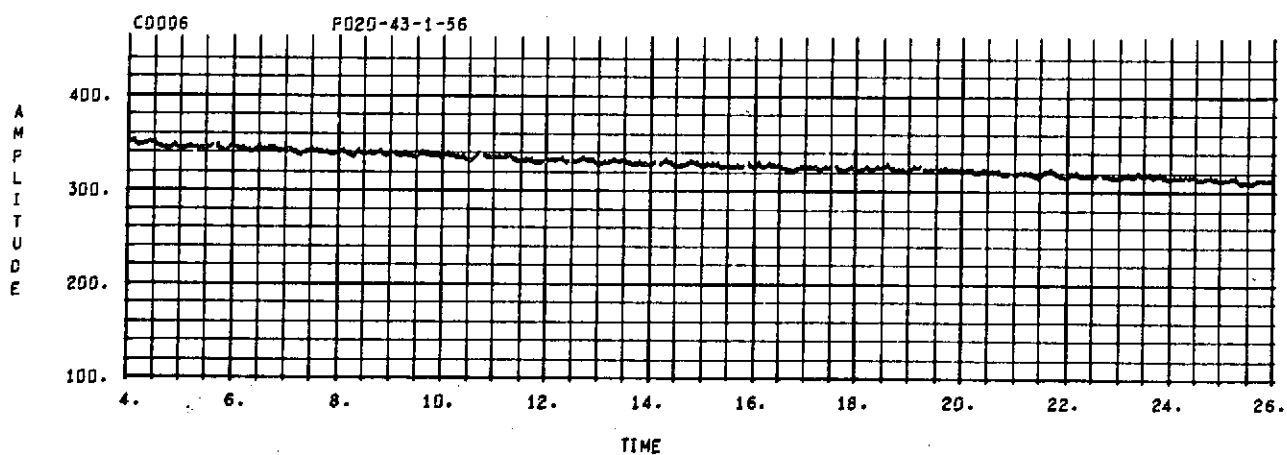
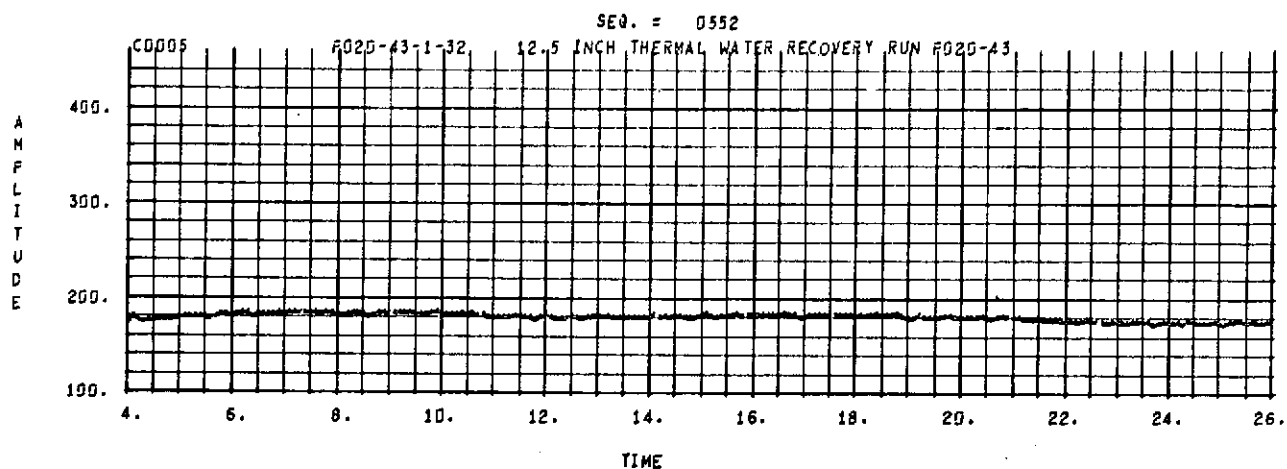




SEQ. = 0552

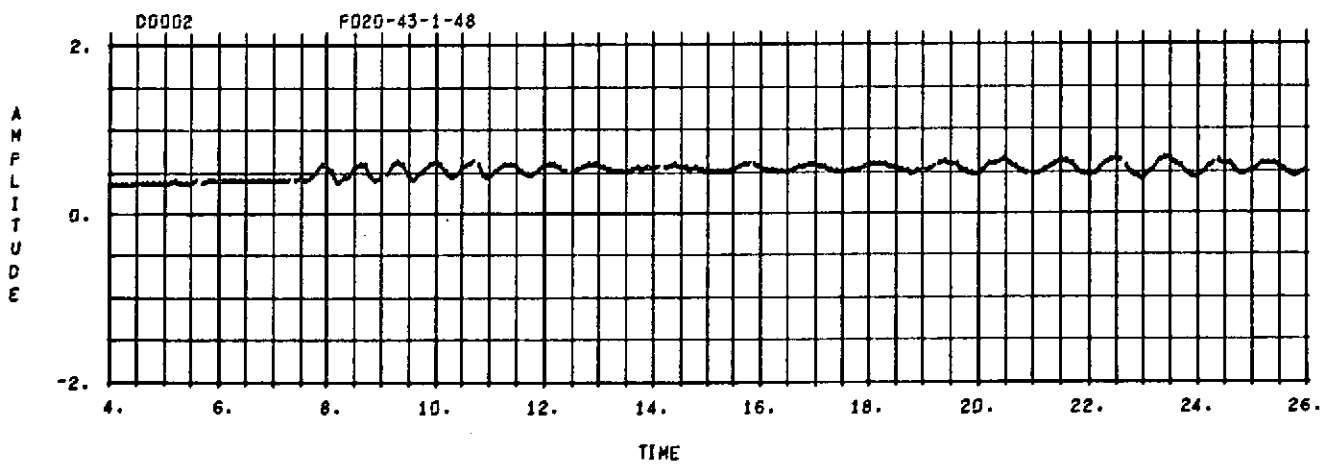
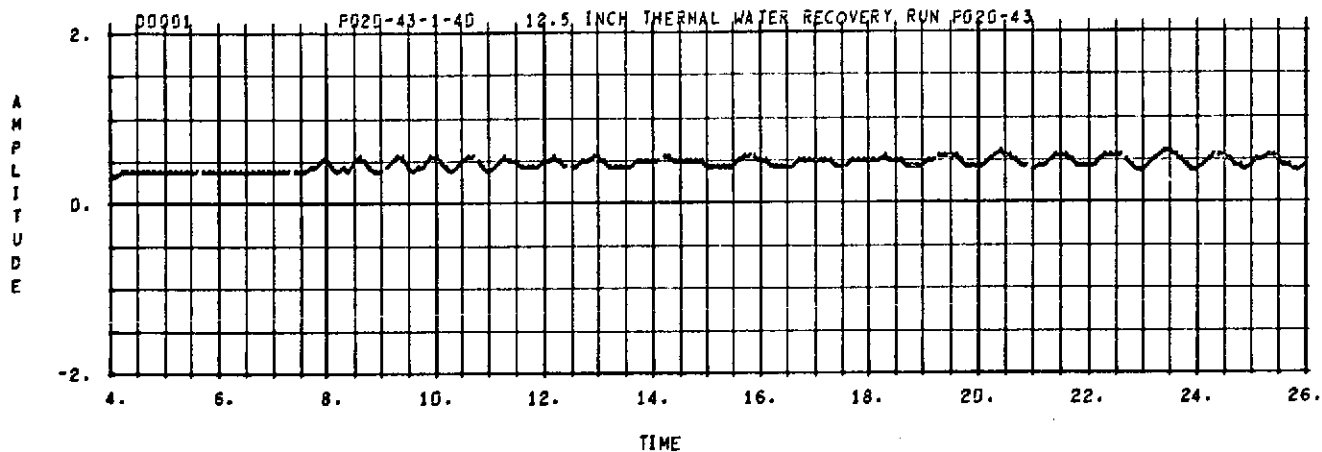
11

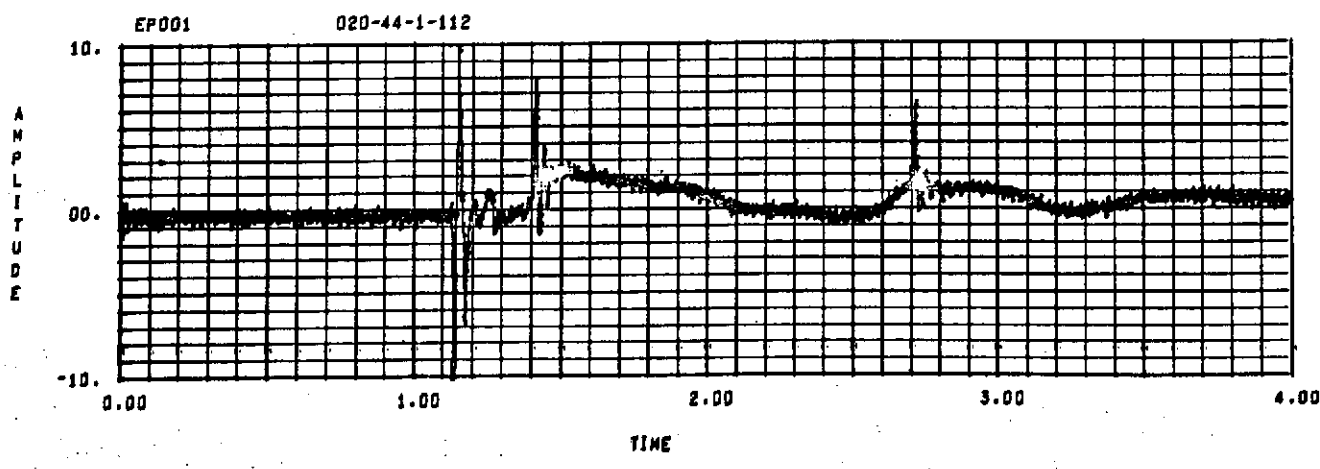
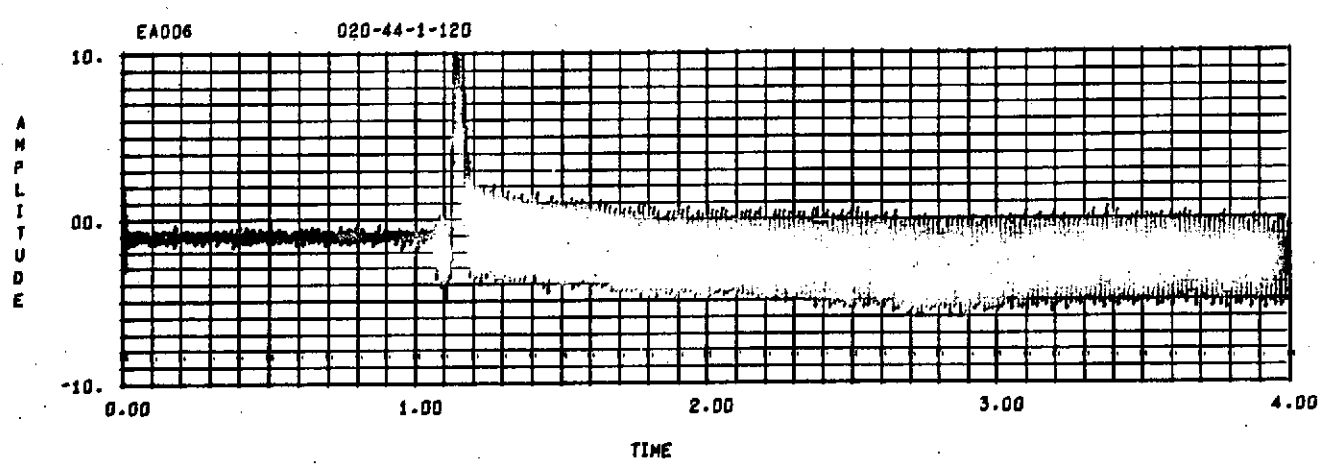
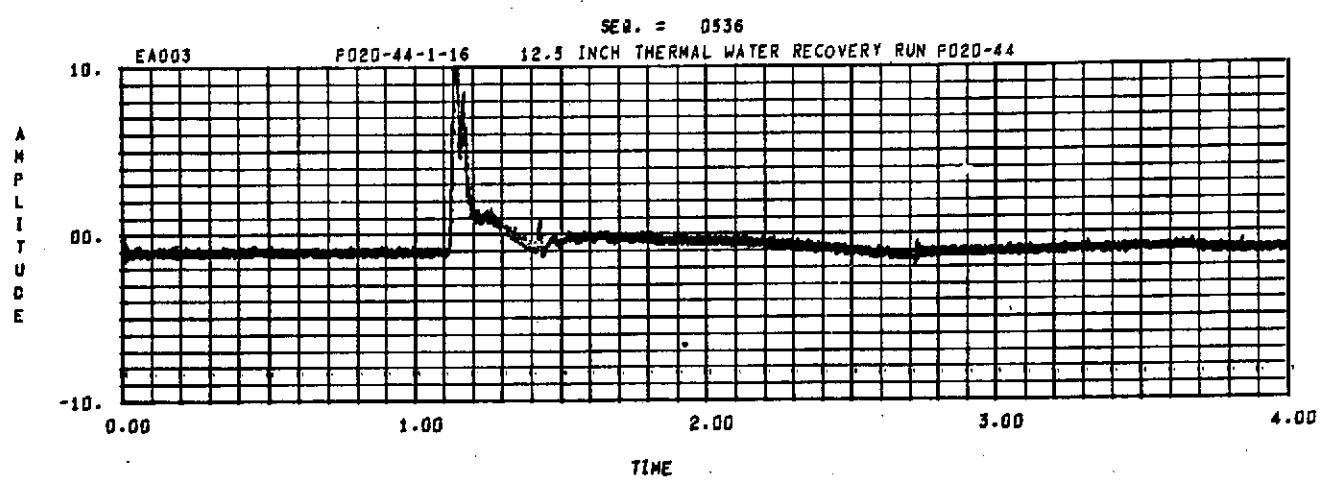




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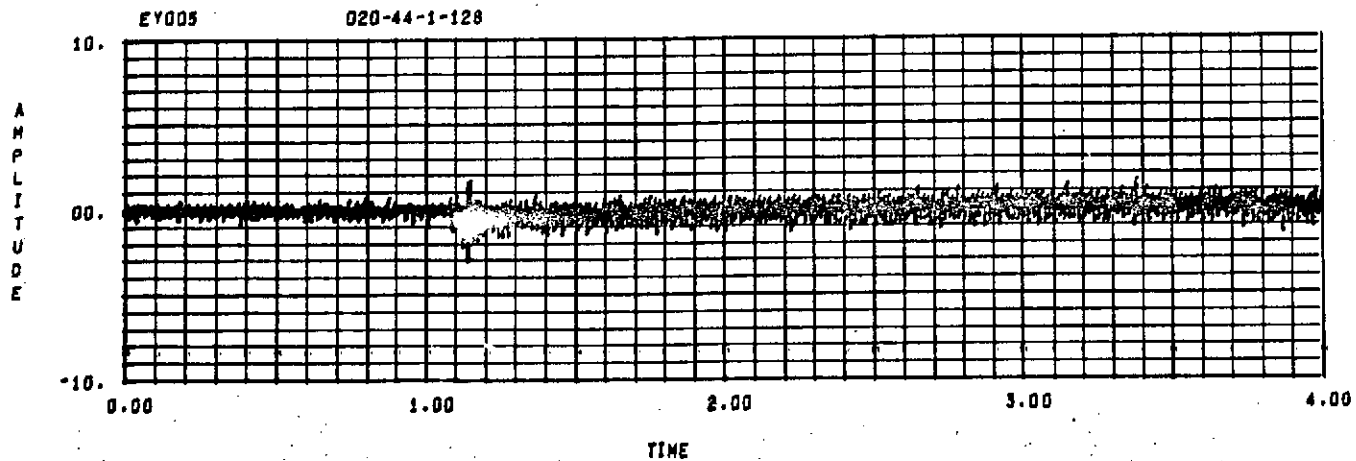
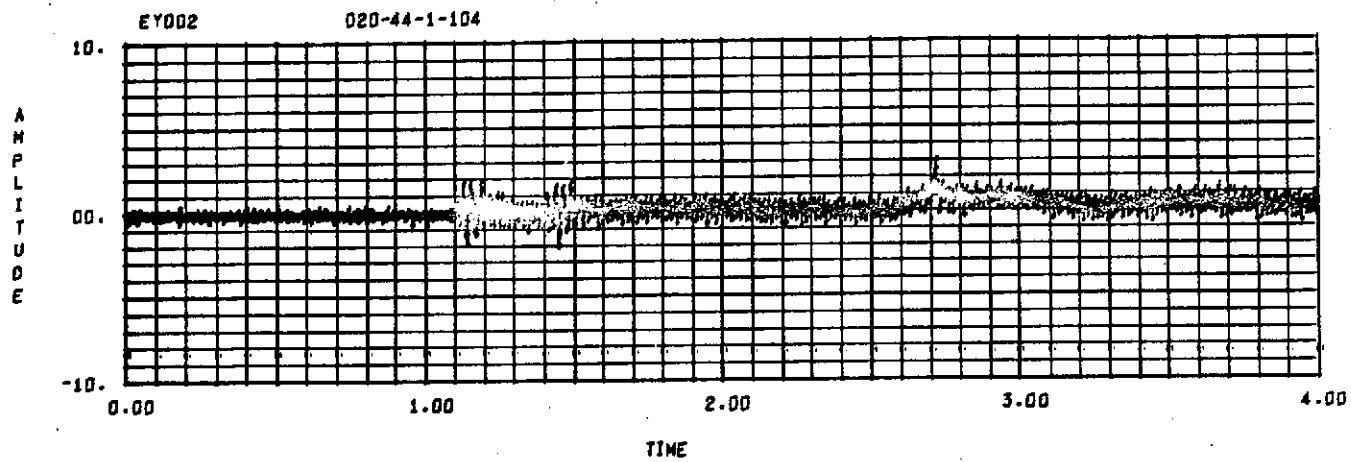
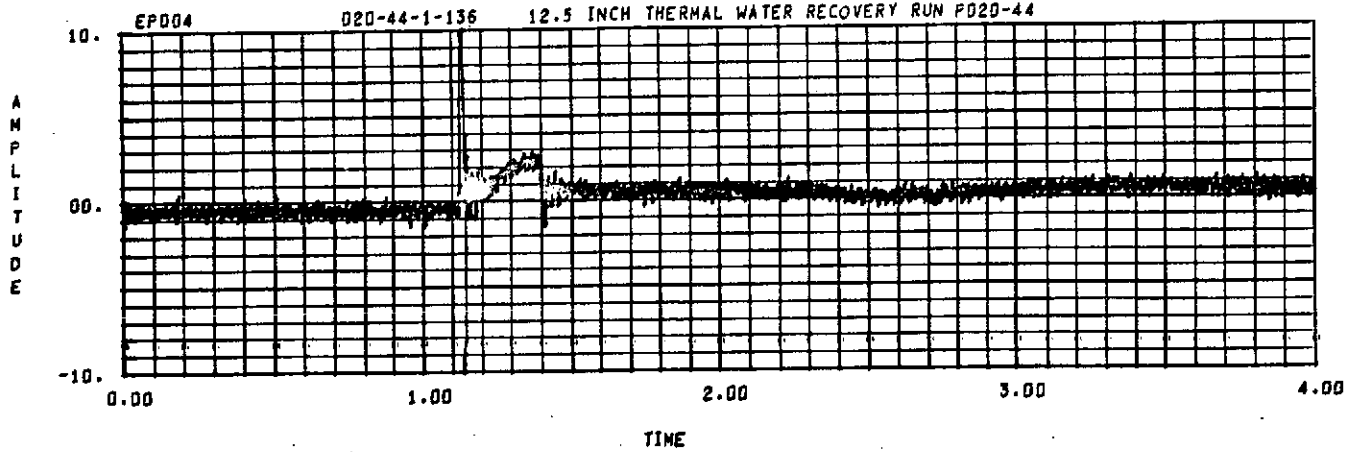
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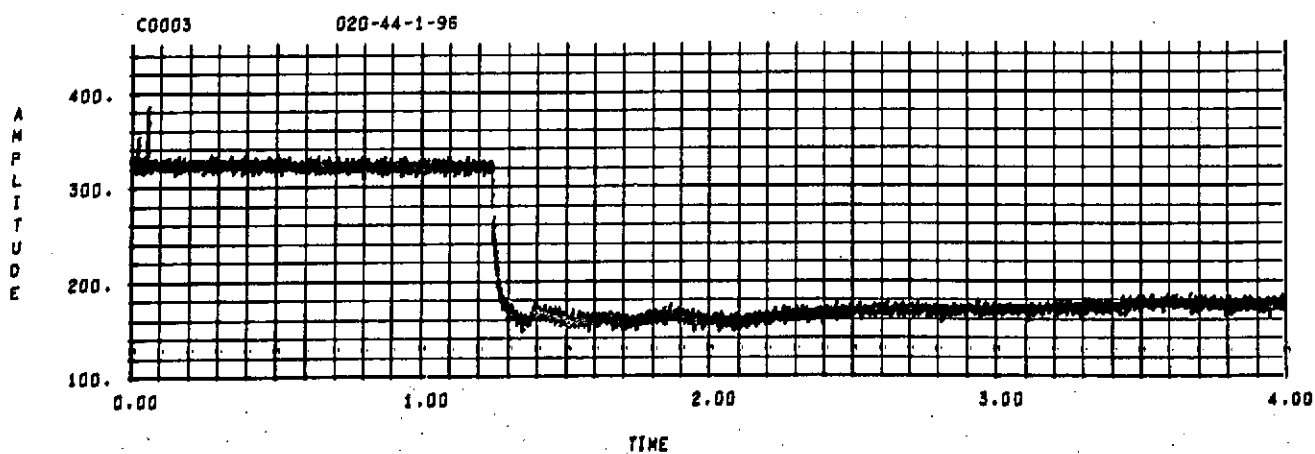
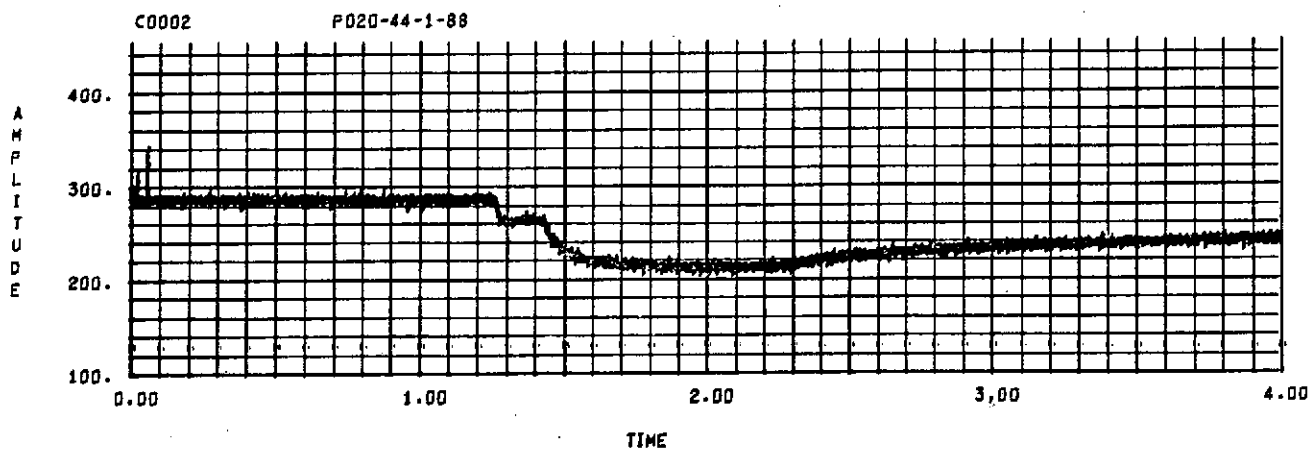
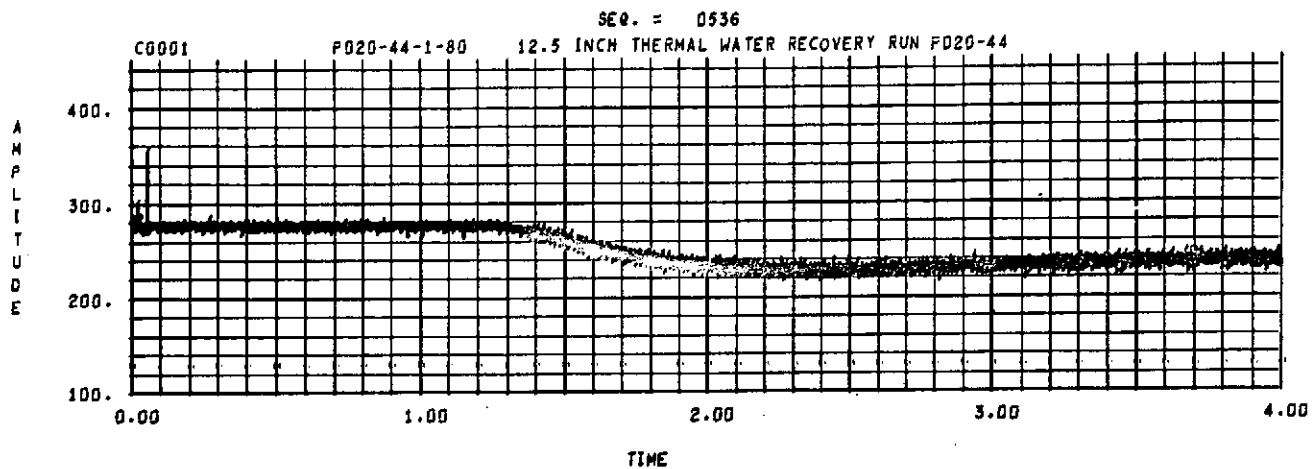




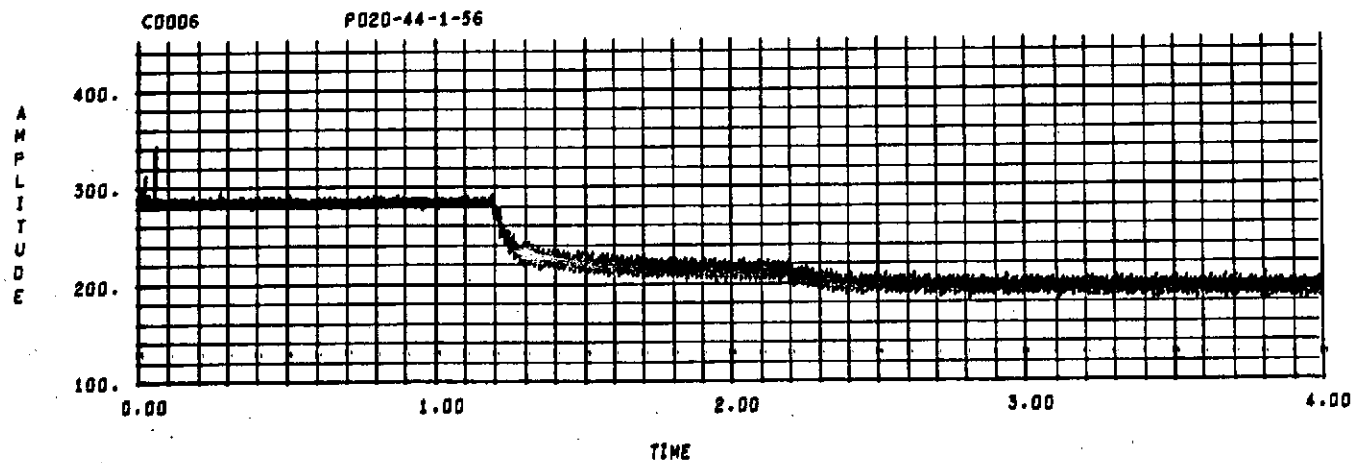
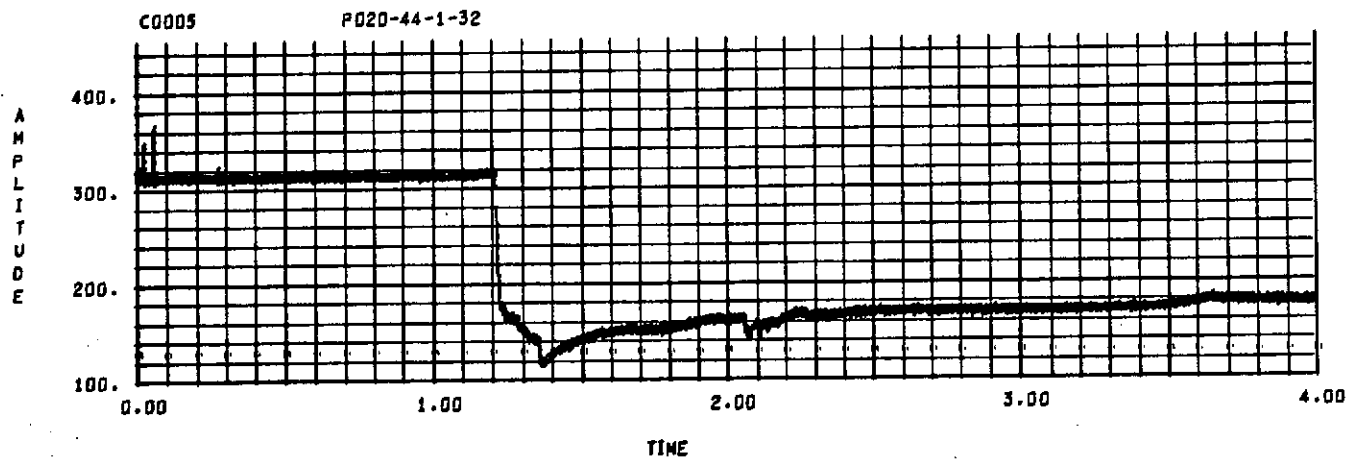
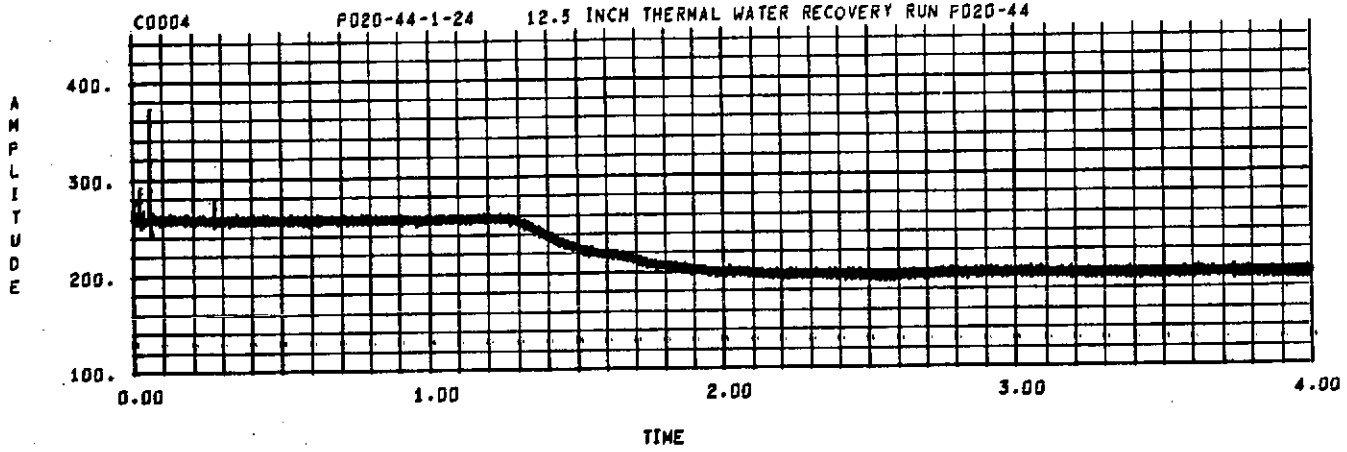
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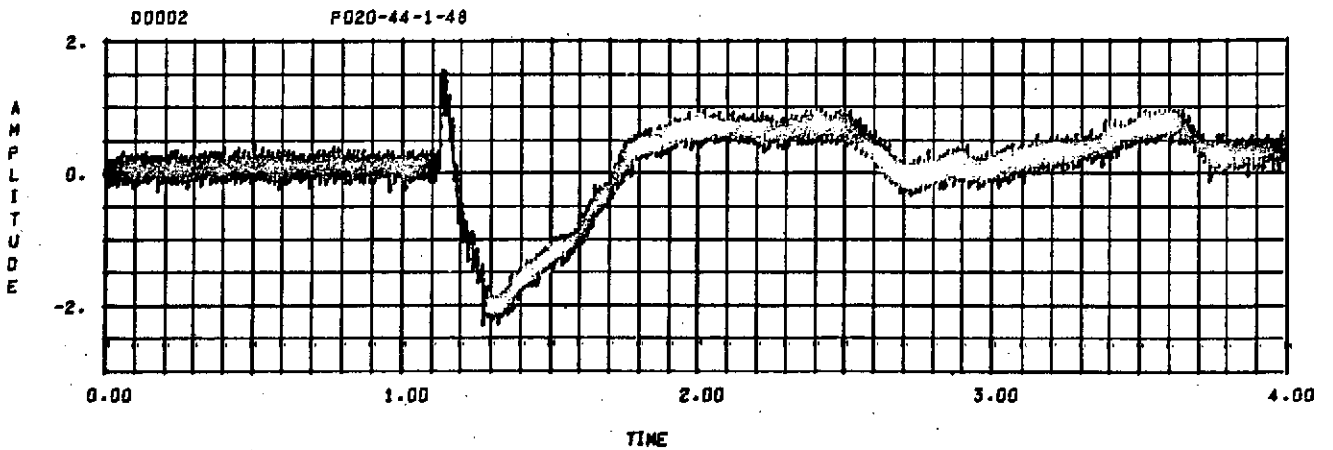
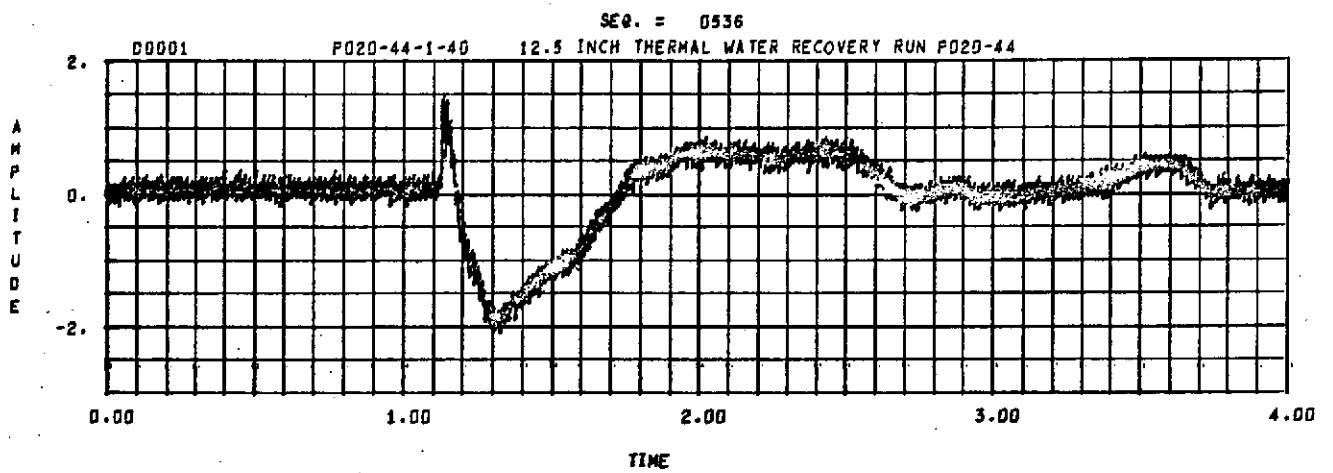
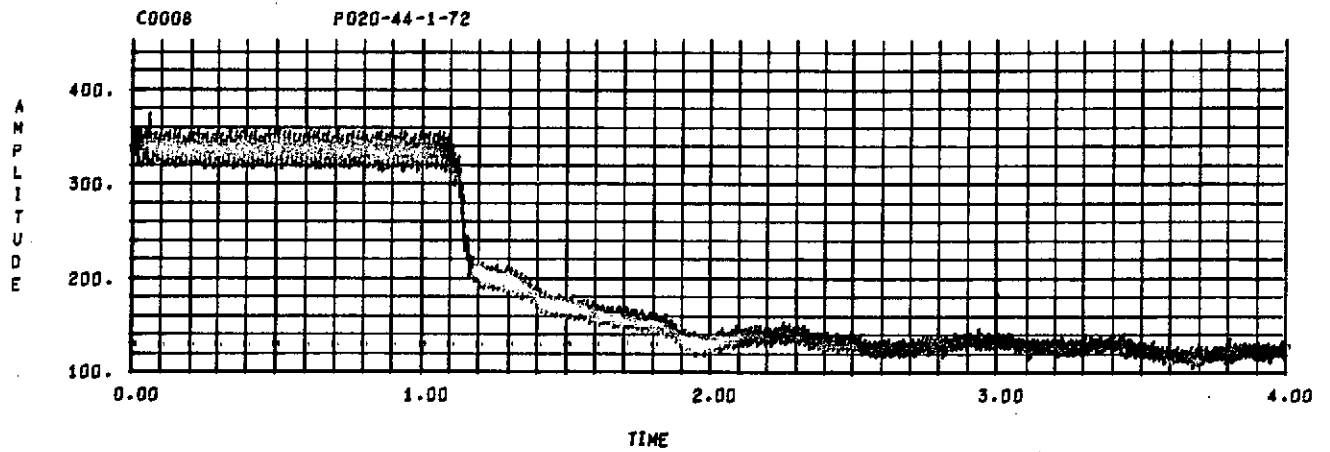
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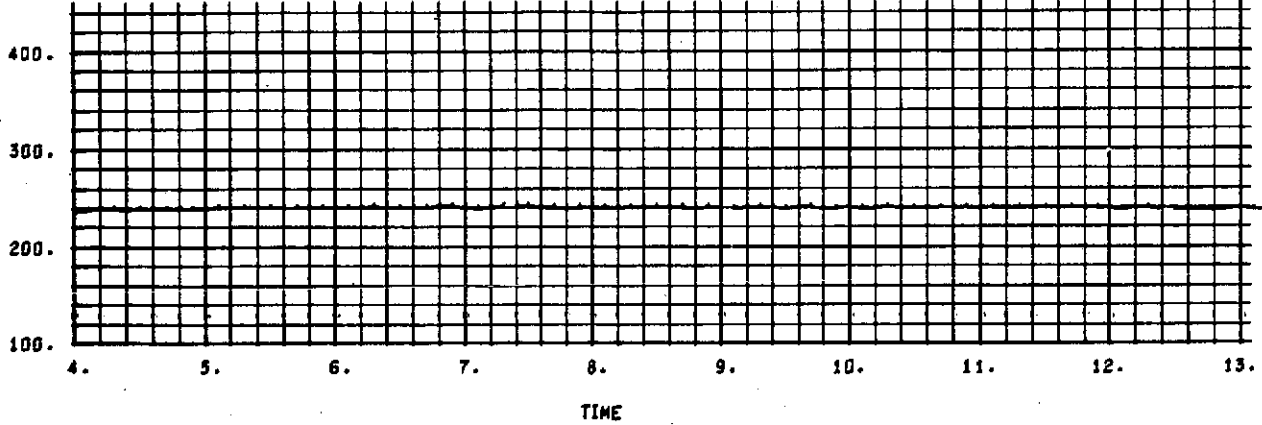


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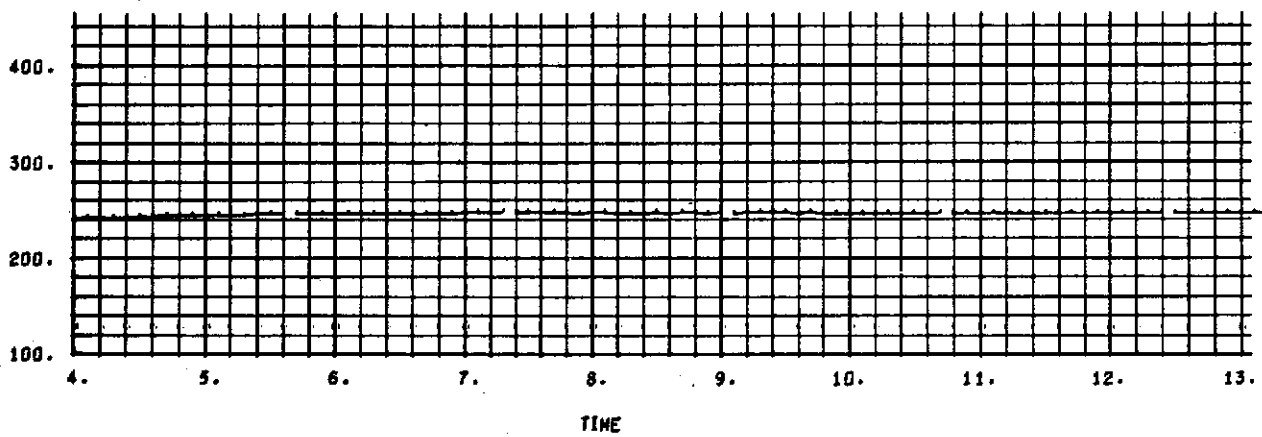
C0001 P020-44-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-44

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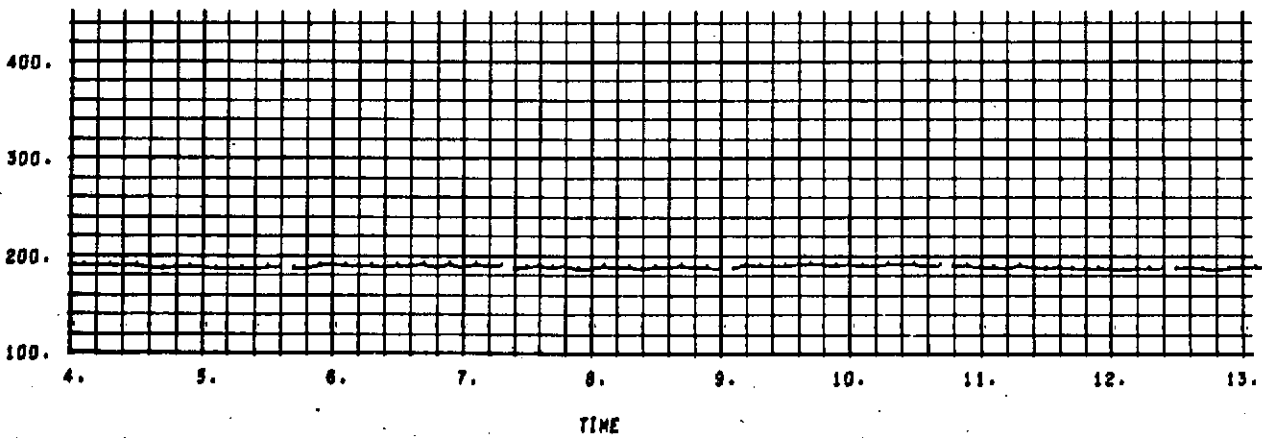
C0002 P020-44-1-88

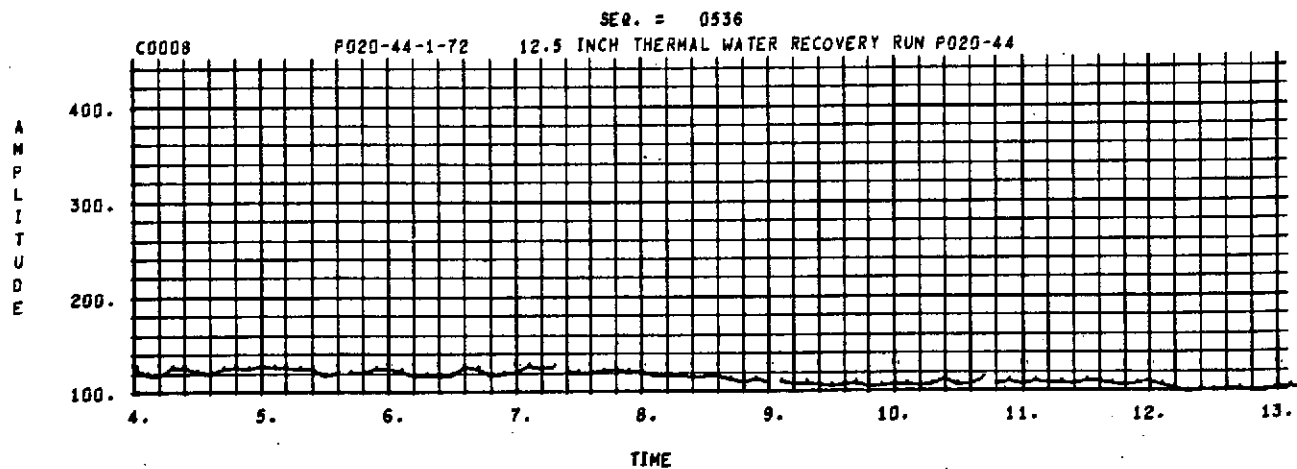
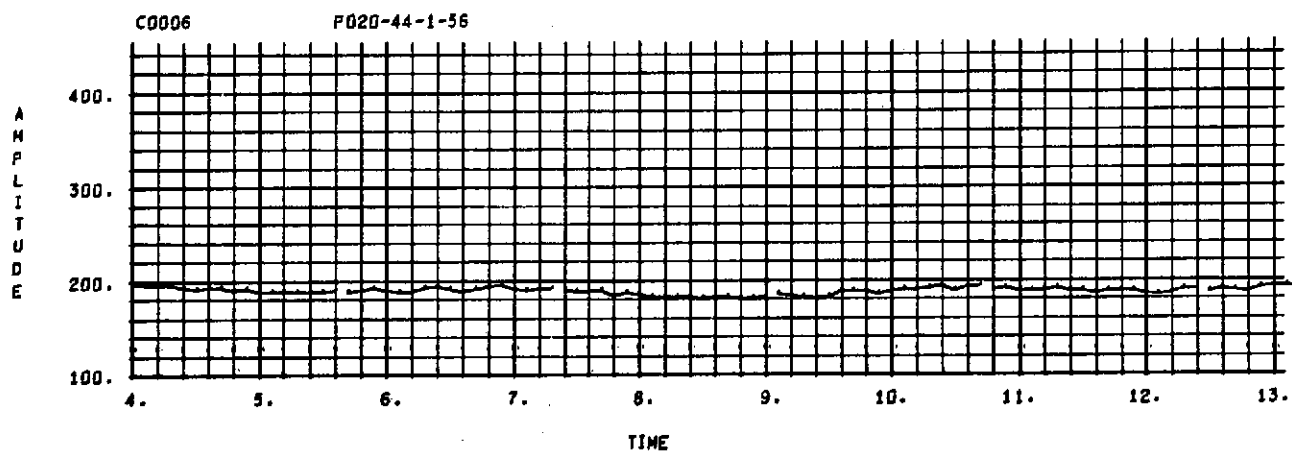
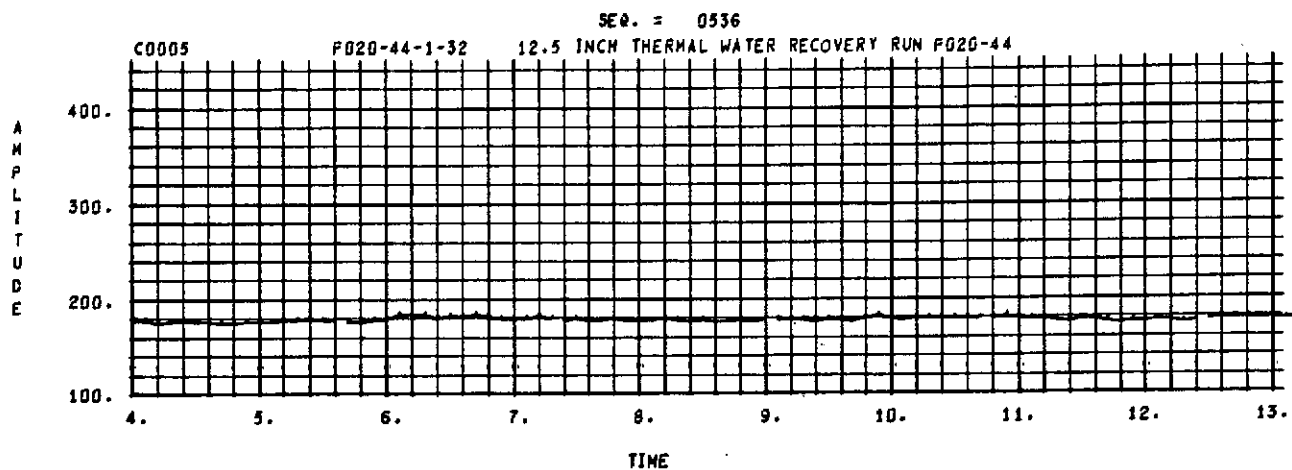
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C0004 P020-44-1-24

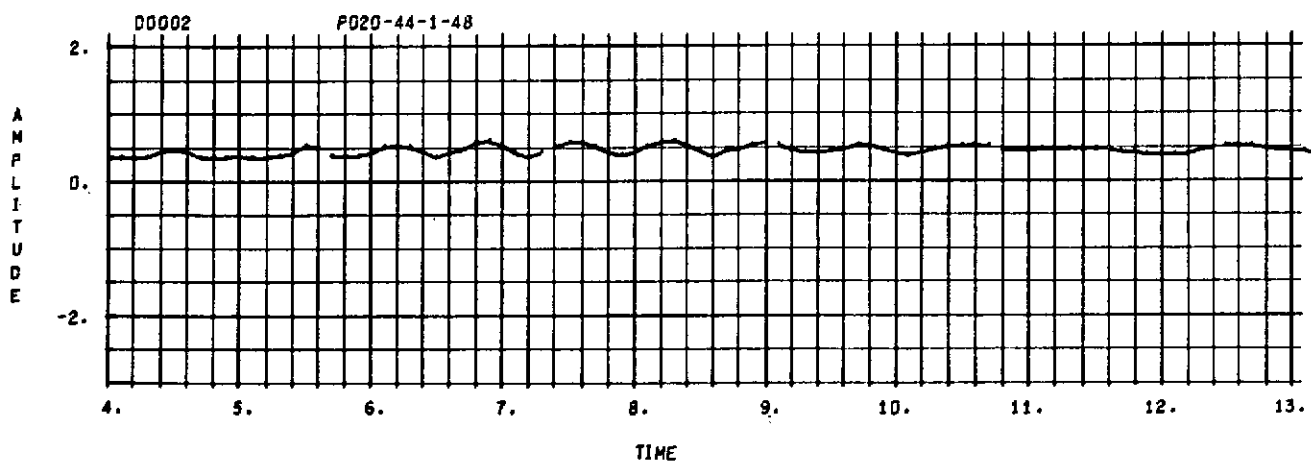
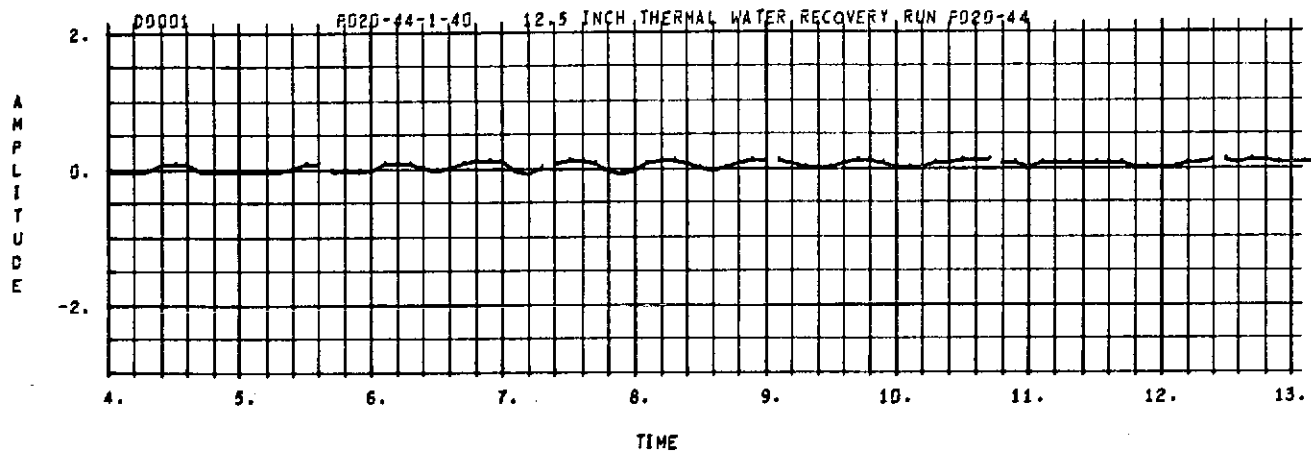
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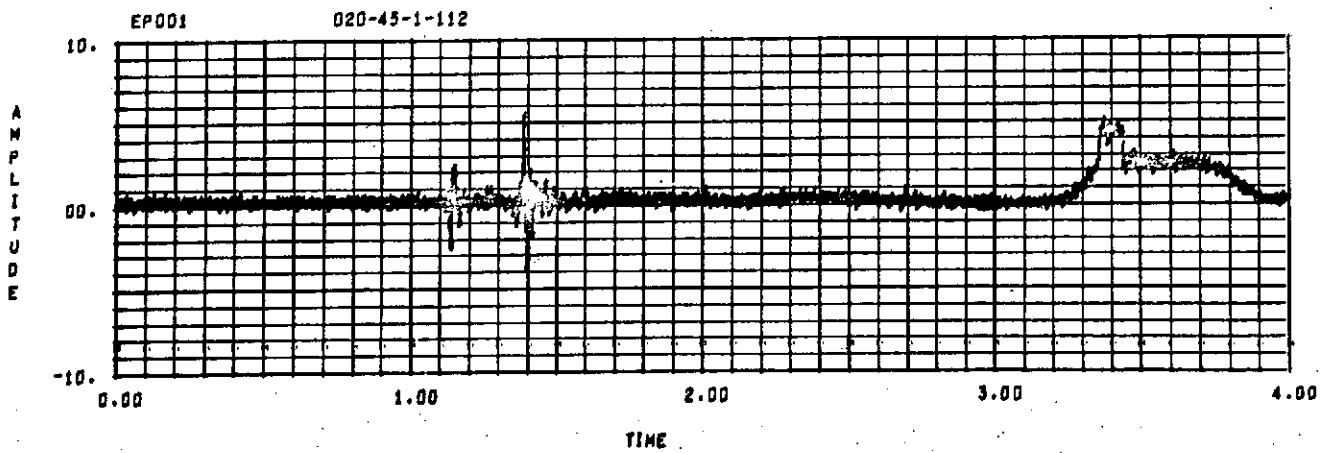
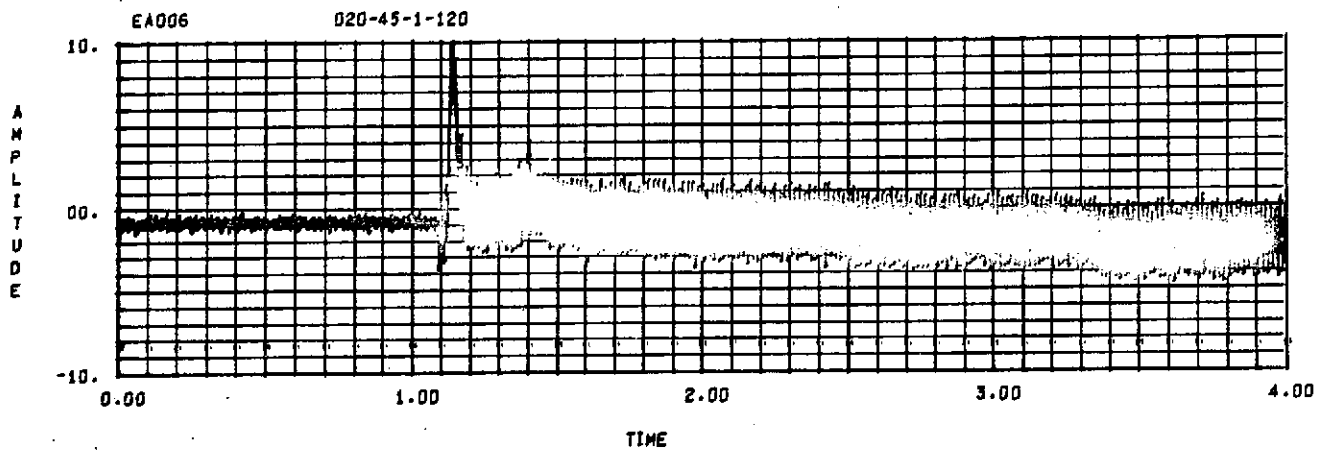
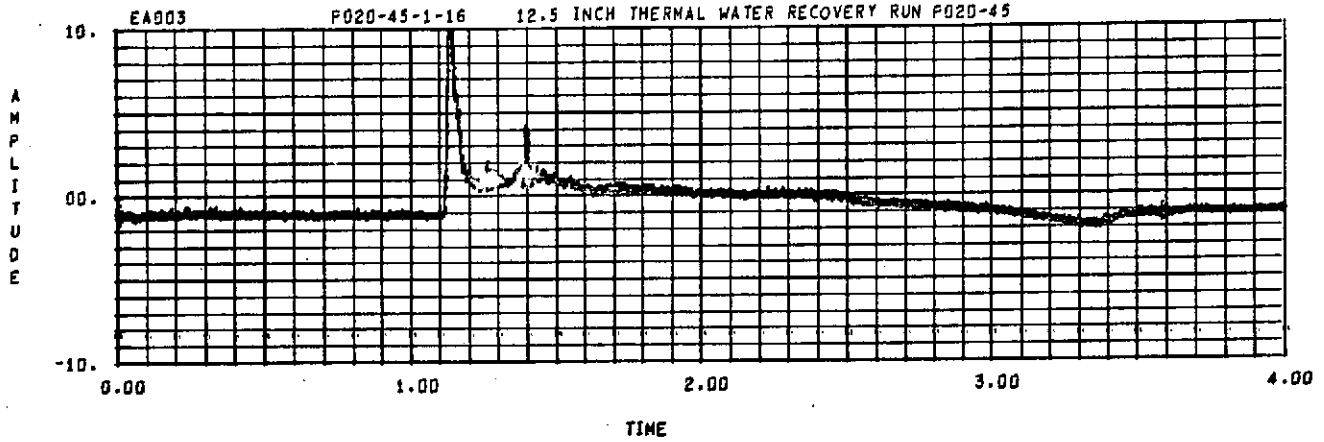
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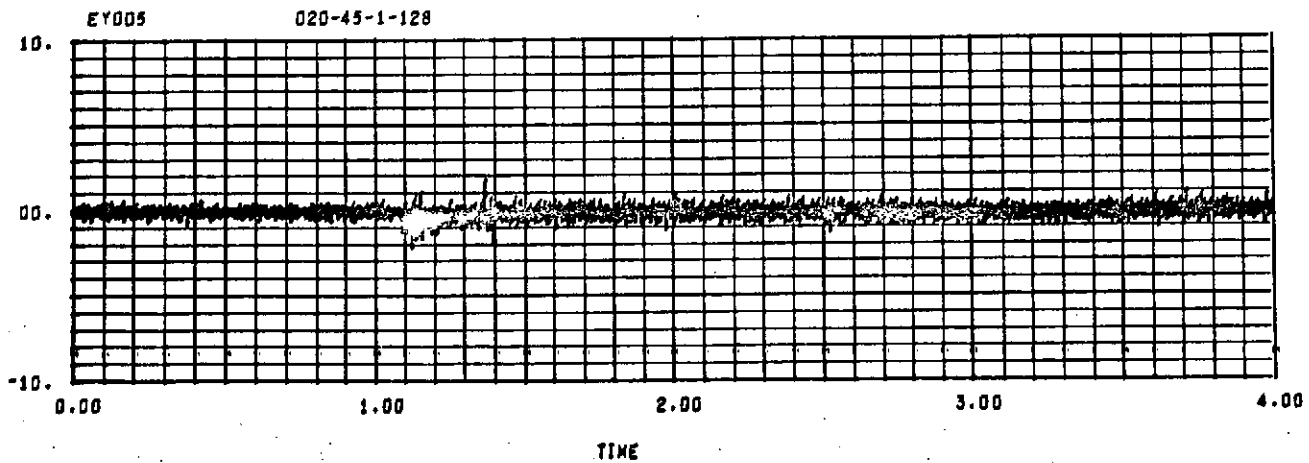
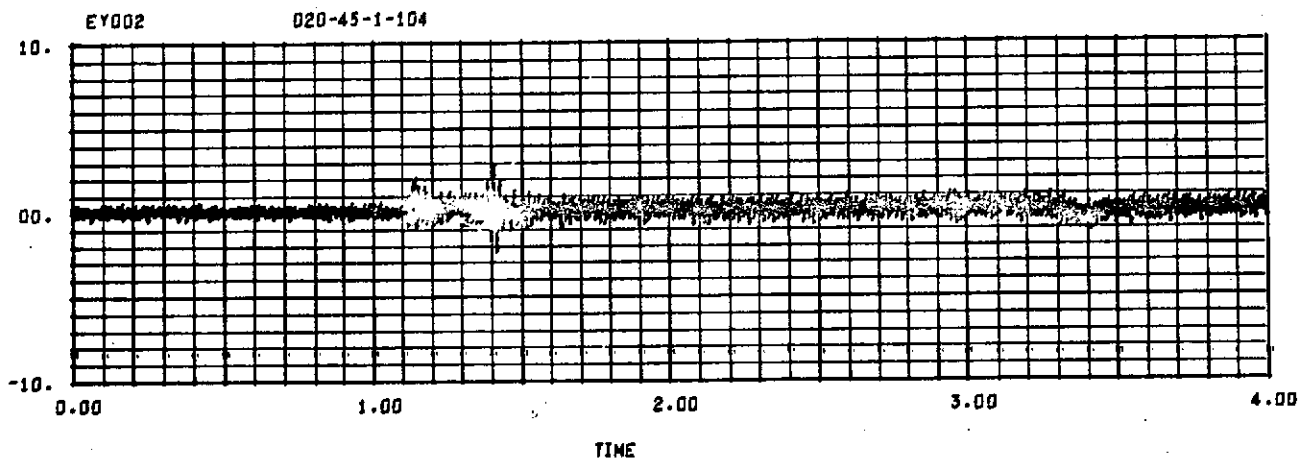
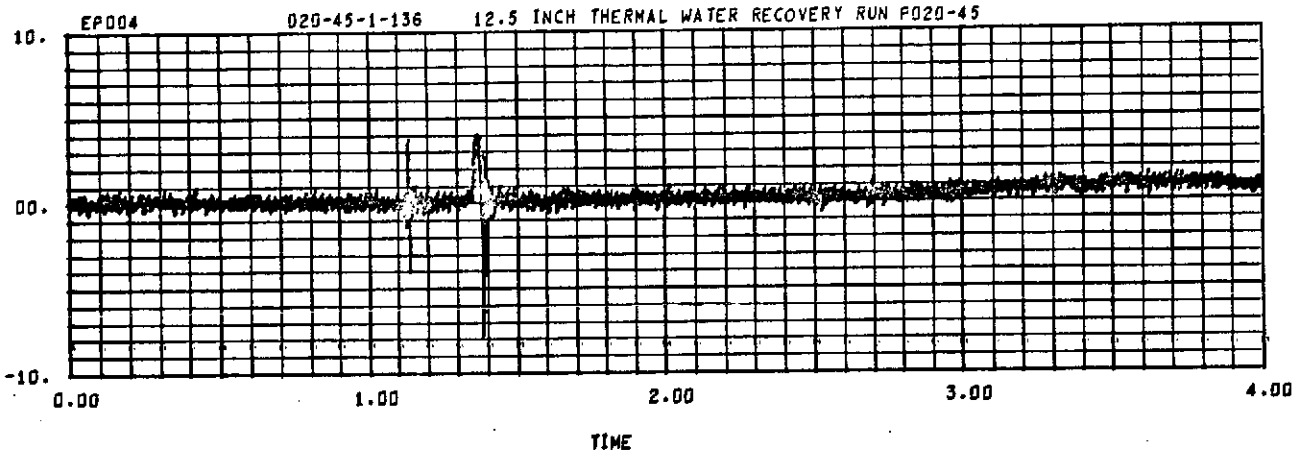
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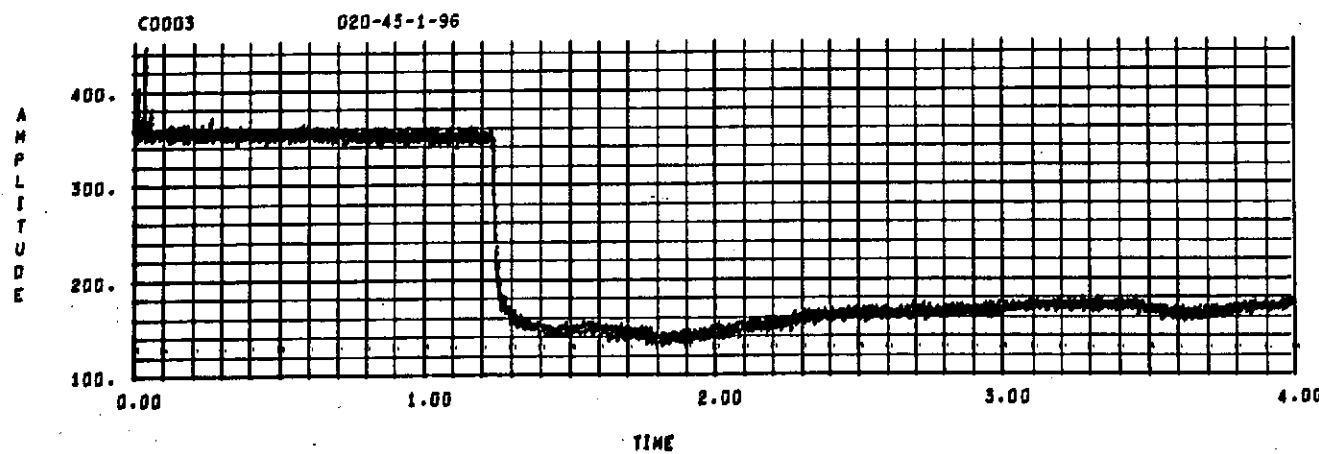
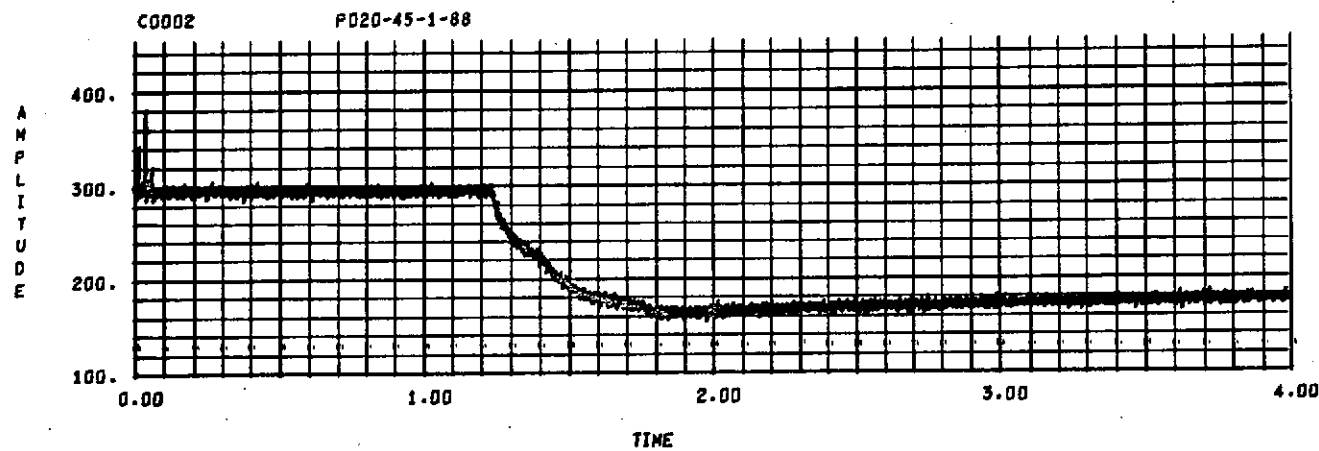
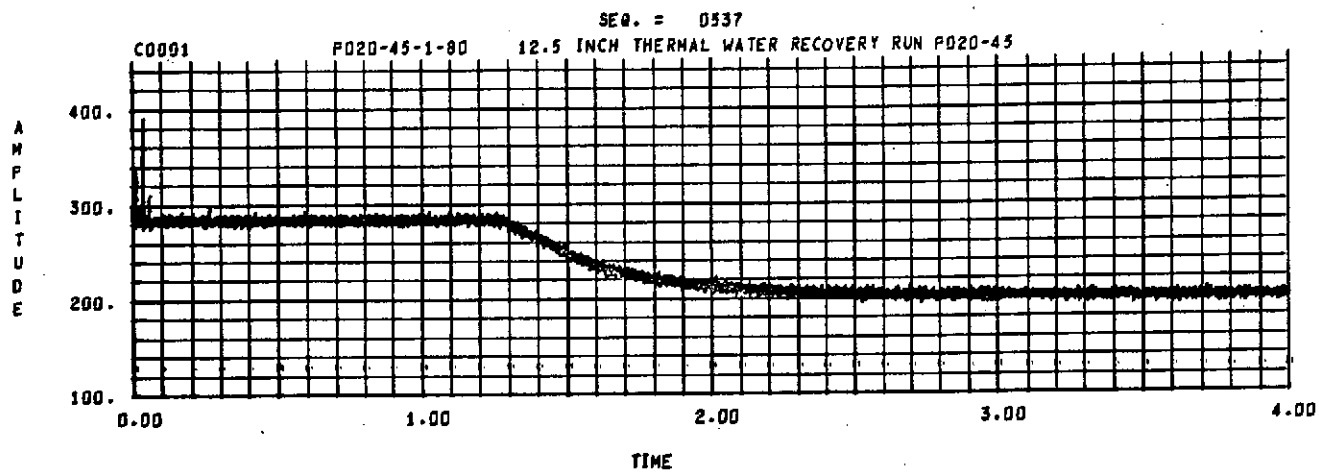
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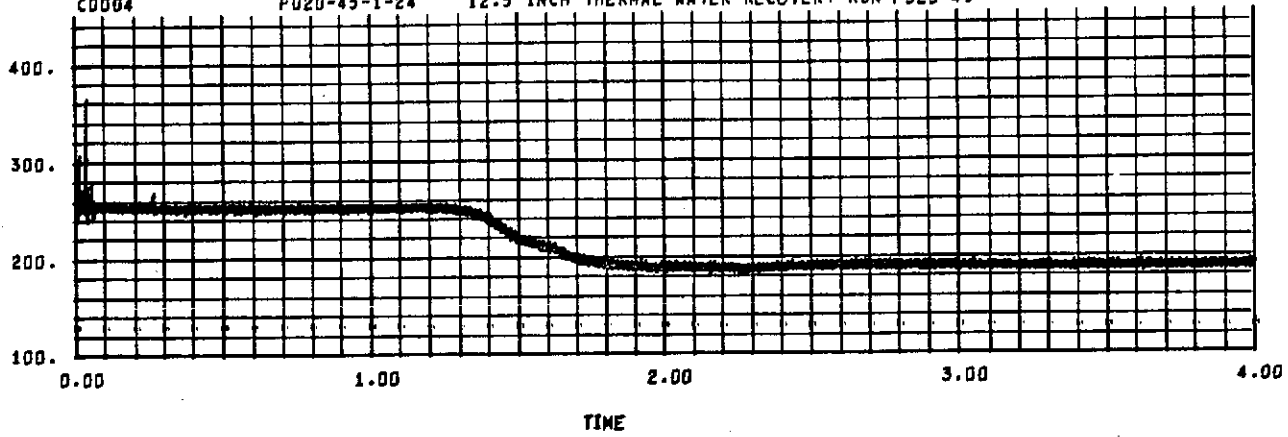


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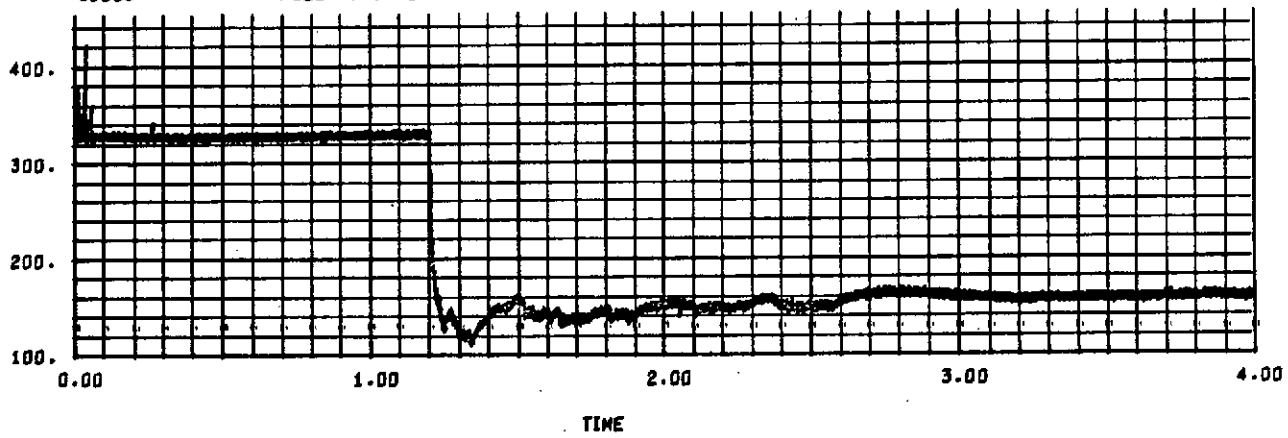
C0004 P020-45-1-24 12.5 INCH THERMAL WATER RECOVERY RUN P020-45

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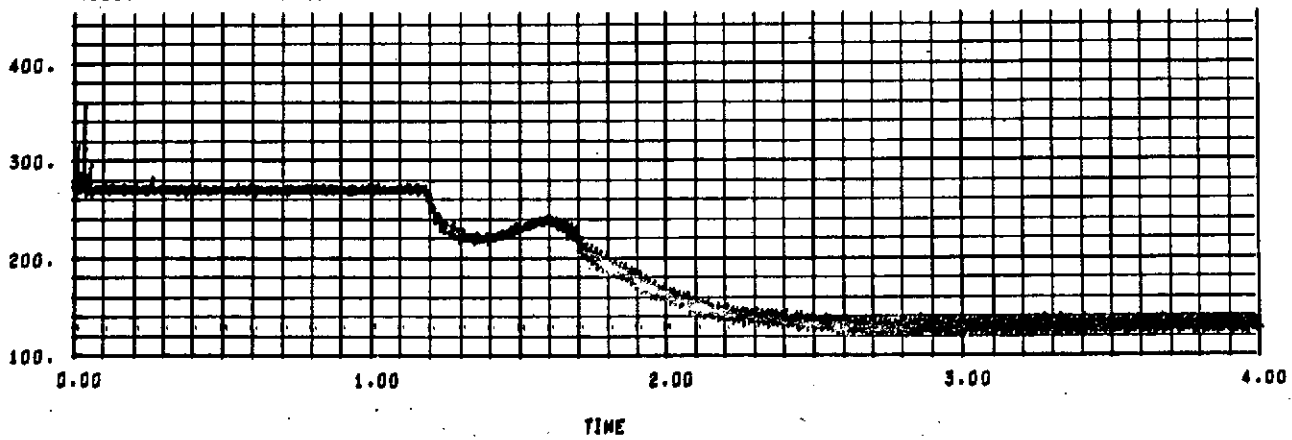
C0005 P020-45-1-32

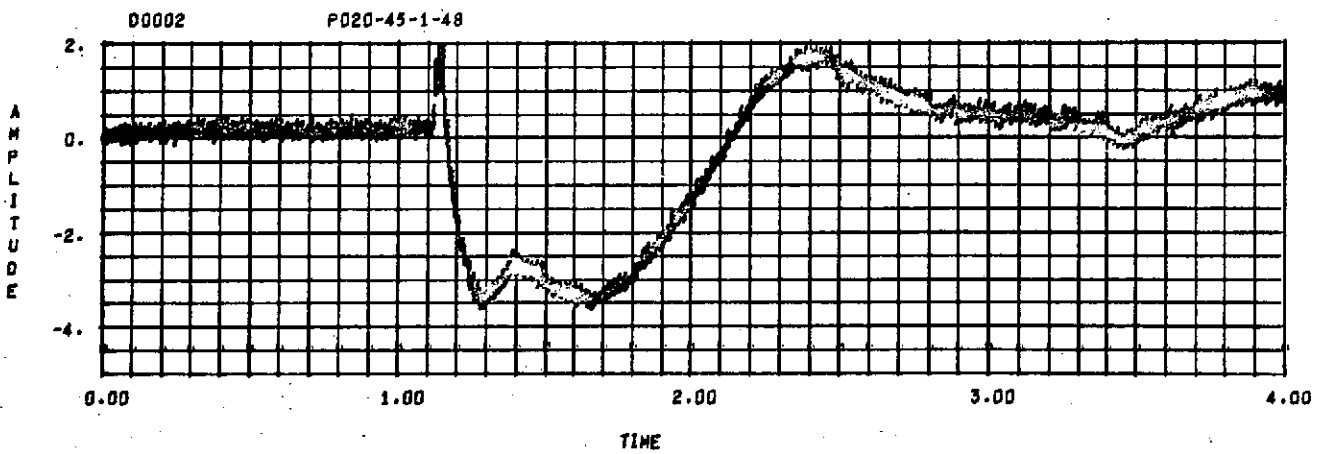
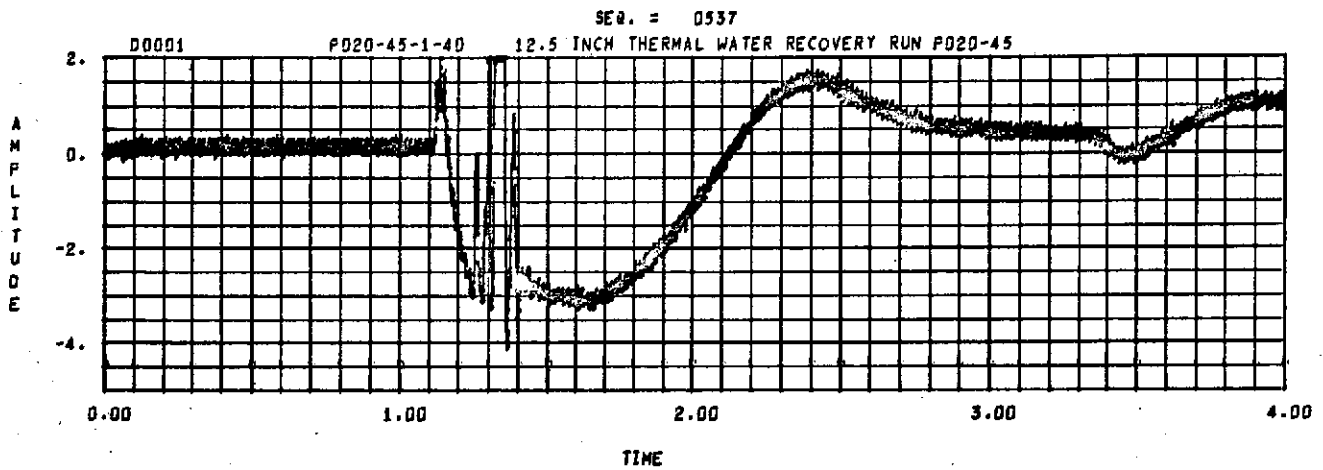
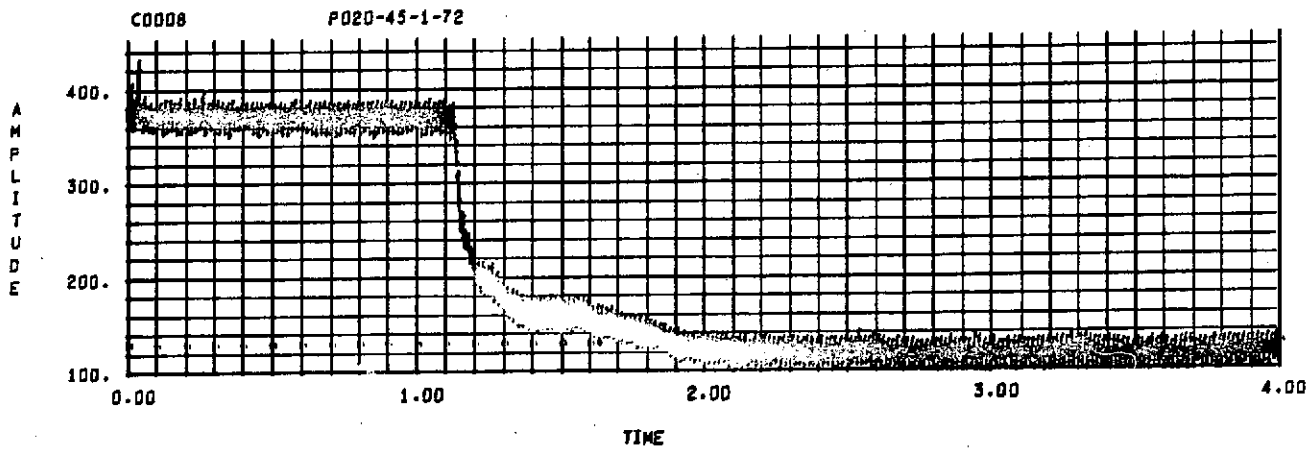
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C0006 P020-45-1-56

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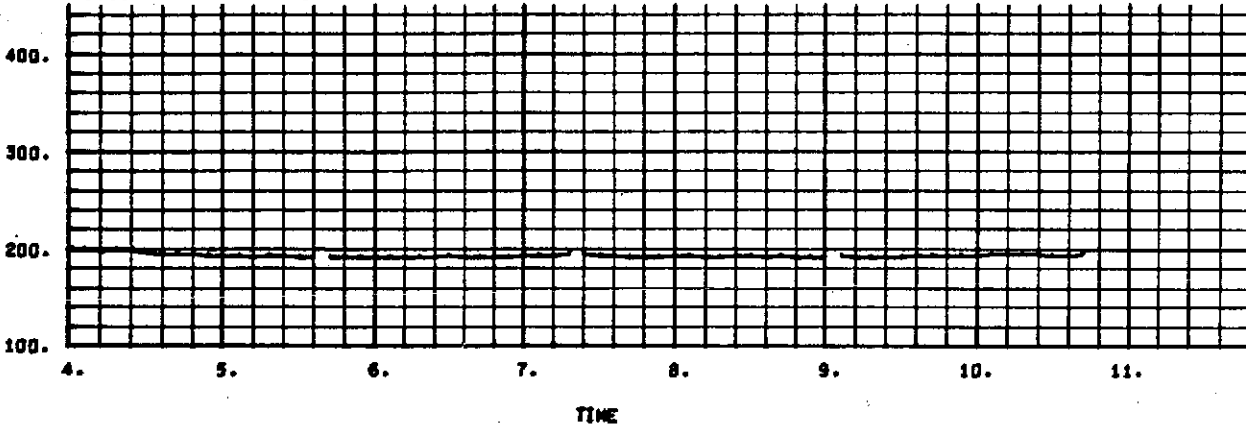


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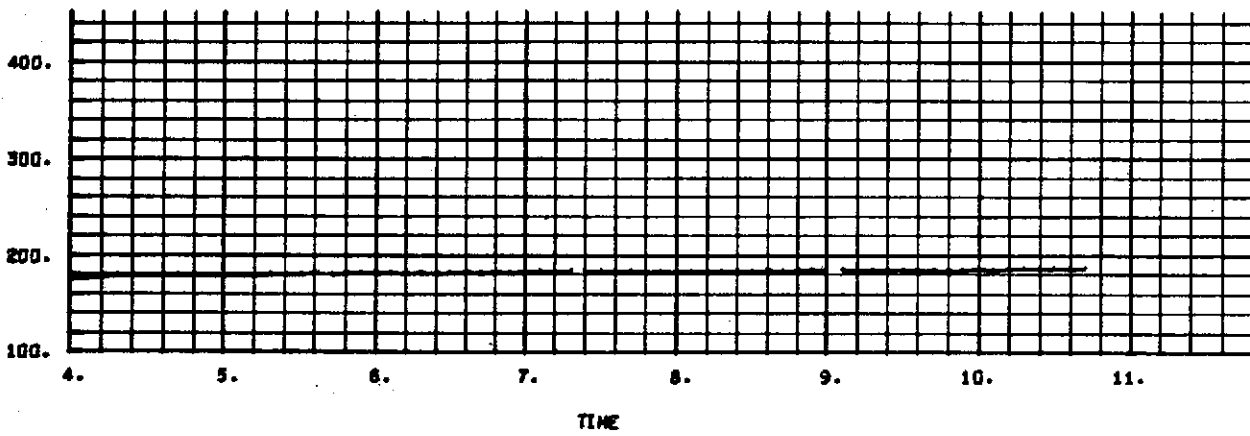
C0001 P020-45-1-80 12.5 INCH THERMAL WATER RECOVERY RUN P020-45

AMPLITUDE



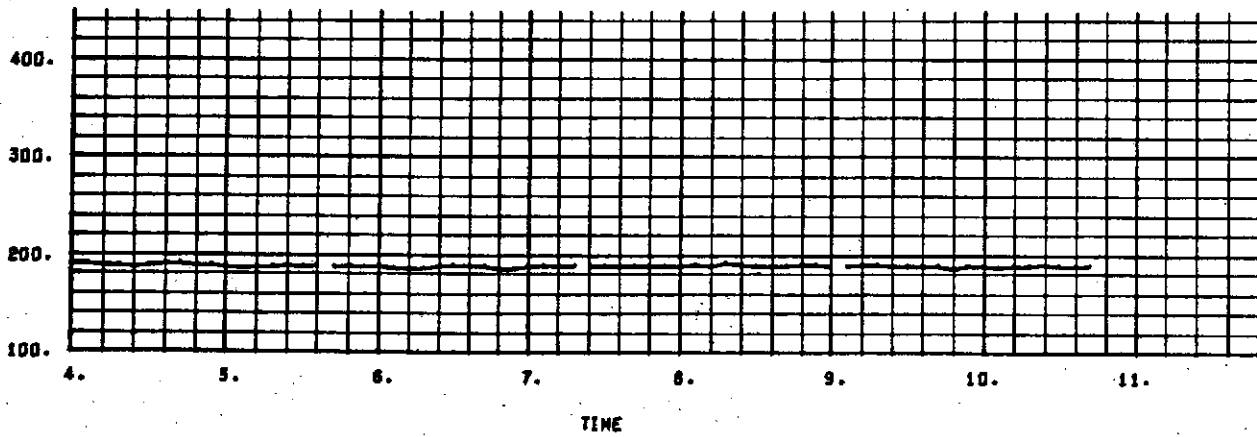
C0002 P020-45-1-88

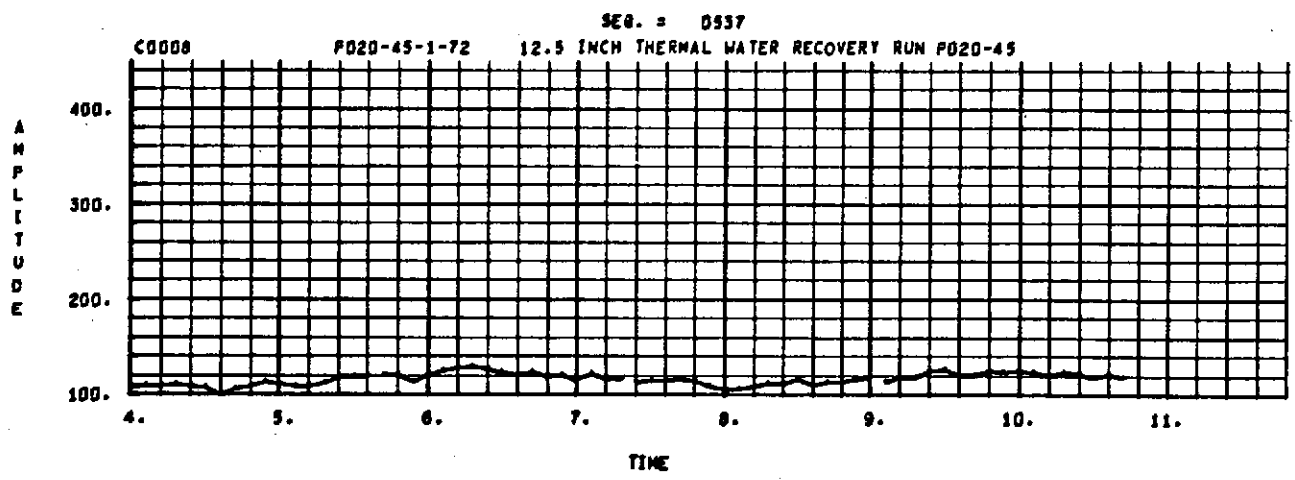
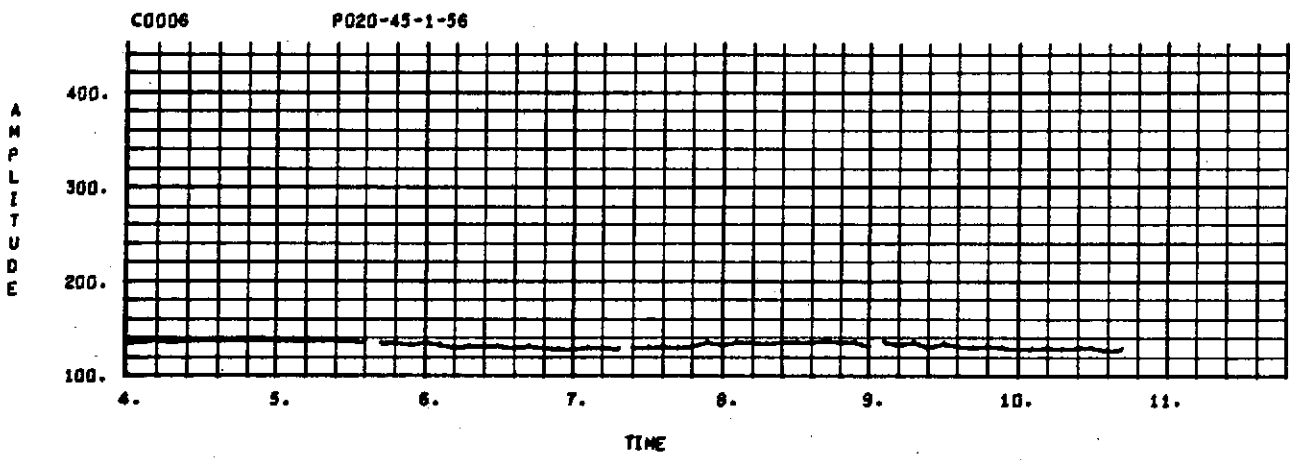
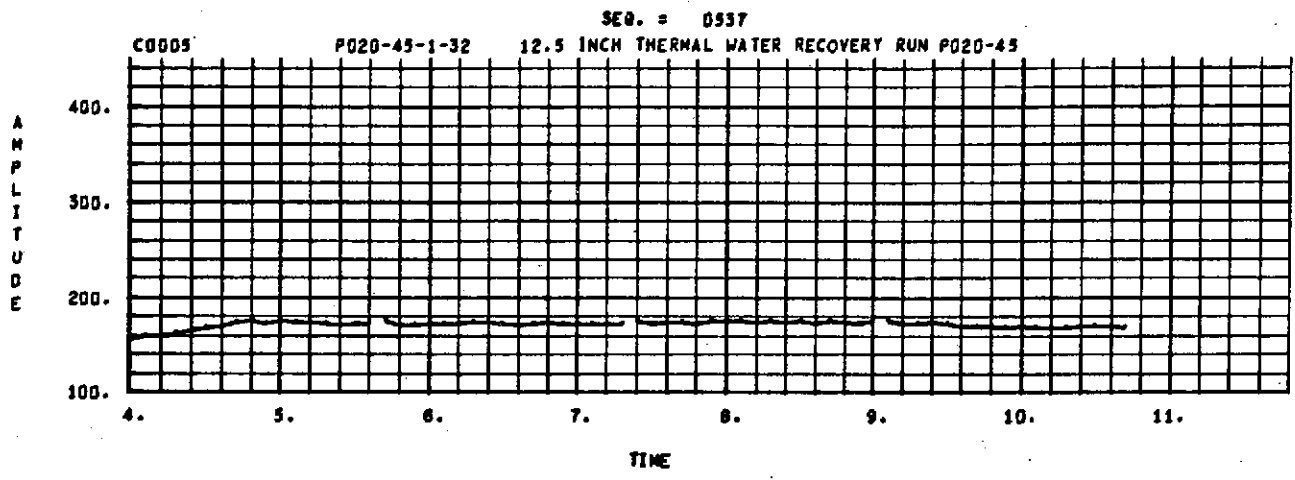
AMPLITUDE



C0004 P020-45-1-24

AMPLITUDE





SEQ. = 0537

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